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Managing a Science Club [1]

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Educational thought and investigation of the last ten or fifteen years have been focusing the attention of teachers, supervisors, educators, and the thinking public upon certain educative forces that exist quite apart from the activities of the schoolroom. These forces are sometimes so vital and so important in shaping the life of the individual that the failure of the educational system properly to guide and control them has brought upon it a considerable portion of the criticism of recent years. Developments in educational philosophy and psychology have been very emphatic in pointing out that what our pupils do during every hour of the twenty-four in the day—and of every day in the year—is a factor making for education and therefore a legitimate consideration for the school and teacher. Thus, we have begun to investigate such questions as home-study play. and nutrition. We have gone into the home and make recommendations to parents in matters which have hitherto been looked upon as belonging only to mother and father. We have begun to lay stress upon student organizations of all sorts; seeking in them value in citizenship and habit formation. Clubcraft, scoutcraft, and camping have become pertinent considerations for the educator and, what is more important, for the teacher in the class room. And, as might be expected, this newer element is having its influence upon our schools, their organization, curricula, courses of study and methods of instruction. The concept that the school is

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not a place where we prepare for a life that is to come, but is an integral part of life itself, must necessarily and in a very intimate way relate school procedures with the vital factors of life.

In a sense, we are preparing our pupils for a future life in the most effective way when we teach them to live better their present lives. From considrations such as these, extra-curricular activities have been deriving greater importance. Eventually the line of demarcation between the two phases of activity should fade completely. The school day may start at 9 and end at 3; but its influence will function at all times. And in turn, methods of work, content, and organization within the four walls of the school-room should take their quality and their inspiration from the well-springs of enthusiasm so common to after-school activity.

Needless to say, we are as yet far from so ideal a development. To the pupil, out-of-school time has always been and still is the period of freedom par excellence. We have perhaps progressed beyond the point where he thinks of the school room as an abode of horrors, of the teacher as an ogre, and of books as instruments of torture; but too often his real life is still essentially distinct from the school. His greatest activity and his greatest enthusiasm still center around the extra-curricular where are to be found problems of his own choosing and ideas born of his own inner urgings.

And society is filled with individuals who look back upon these two phases of their past lives with two quite distinct attitudes: with censure, criticism, and unpleasantness for the one; and with glowing recollections of the time profitably spent for the other. It is a very wide-spread reflection upon American college education that it is essentially an extra-curricular training. In some colleges it is frequently a matter of disrepute to have devoted much time to studies. The same condition holds for the high school and in a different sense even for the elementary school. The man of sixty who reviews his life and concludes that his real education was what he got while in contact with the world of actual experience is often paralleled by the high school or college student who regards as his real schooling his experiences of out-of-school

life. "He has nine months in which to get his schooling and three months in which to gain an education."

From every point of view possible, extra-curricular activities loom up as immense factors of educational importance. In the field of science there has always existed a body of materials and experiences that were essentially tied up with life out of school. Before the great industrial changes which brought to civilization the "factory", and which herded our masses into congested cities, the home was a center of industrial, social, and intellectual activity. In this activity were found a stimulus and an opportunity for experiences of a physical, mechanical, and manipulatory nature. This stimulus ex-vity and his greatest enthusiasm still center around the extra-seventy years ago, nevertheless made one of the largest contributions to the intellectual development of the individual of that day. As modern industrialism continued in its growth, the home ceased to function in the old sense. Education became more and more "curricular" and systematic, "squeezing the educational juice" out of the home.

In the last ten or fifteen years, there has come into existence a substitute for this lack of manipulatory and sense-experience in the modern city home. A mass of science play materials has invaded the apartment house. The boy spends large portions of his time on them; and the parent often stints himself in order that his boy may have them. In the matter of time expended, effort exerted, interest aroused and thought provoked, these materials and activities compare most favorably with what the same boys do *in school.*

The science teacher, in particular, is affected by this activity which goes on outside of his classroom. Sometimes he uses it for his illustrations, sometimes he make use of the toy apparatus, sometimes he cautions against certain undertakings, and sometimes he opposes an activity and rules against its worthwhileness. But more frequently there is but one effective way of organizing and guiding such intense interests as the one in Radio communication, for example, or in experiments with Chemistry Outfits, and that is, to create a Radio Club or a Chemist Club, etc.

More and more each year, private commercial enterprise is stimulating and feeding the inherent interest of the boy in the

mechanical and other manipulatory devices. Instead of waiting till high school or college years before meeting at first hand and in a crystallized form some of the manifestations of the laws and principles of physics and chemistry, the boy of *ten* now posseses such toys as:

"Experiments with Light"
"Experiments with Magnetism"
"Experiments with Water and Air"
"Chemical Experiments"
"Experiments with Sound"
"Meccano and Erector"
"Experiments with Electricity"

and even such toys as "The Mineralogy Set", "The Surveyor's Outfit", and "The Glass Blowing" and "Soldering Outfits".

It is a most important fact that the period in a boy's life which might be designated as the "toy age", corresponds very closely with the so-called "gang age". The social instinct which begins to show itself to a marked degree during Adolescence finds outlets in one way or another. The Toy Manufacturers vieing with one another for the trade of their little customers have been organizing elaborate clubs and circules of boy scientists and experimenters. The Gilbert Institute of Engineering, the Chemcraft Chemist Club of America, or the Meccano Guild are each vast Science Clubs more or less organized, more or less effective, more or less in competition with each other and each with a program of activities, prizes, honors, diplomas (and even degrees) that make use of an inherent instinct, essentially for their own gain. Without minimizing the very real educational value of these toys and the "institutes" which the manufacturers have woven around them, it does seem that so genuine and keen an interest should legitimately fall to the teacher for development; instead of serving exclusively for advertising propaganda of a very excellent kind.

The club in its relation to after-school activities in science holds forth great promise as an instrument for education. But unless the average teacher be aquainted with the many pitfalls that club-leading presents to the novice, even the most enthusiastic of us will suffer severe discouragement.

And so, to be of some practical aid to science teachers who recognize the value of and are inclined to try their hand at managing a Science Club, the writer wishes to present his experiences with three matters involved in such an undertaking:

(a) The nature or character of the club
(b) Its organization
(c) Its program of activities

First, as to the kind of a science club one can manage successfully with pupils of Junior High School age.

(a) TYPES OF SCIENCE CLUBS

Almost every wide-awake teacher of science has in one form or another attempted to enhance the interest in his subject by organizing after-school special study groups of some sort. Educational magazines abound in descriptions of such groups and their methods. In 90 per cent. of the cases that the writer has read or known about, these groups or clubs tied themselves to one very specialized interest. Sometimes it is a Radio Club. Sometimes it is a Field Trip Club, or a Photography Club or an Aero Club, or an Automobile Club; or a Chemistry Club; or a club for the study of some other special subject. The experience of these specialized clubs is very aften short-lived. The chief sources of difficulty are two. First, the prime movers in the group lose their influence on the majority; because they advance so rapidly that the rest feel hopelessly outclassed. Second, the progress of the very few leaders in the club soon exhaust the knowledge, ability and equipment of the average teacher in science. Where the latter is not the case the group continues; but it becomes very limited and select, establishing an "aristocracy of scientists". This of course is of immense value to the "aristocrats", but it doesn't at all utilize the possibilities along these lines that the mass of individuals possess.

In contrast to this type of club, we have the "General" Science Club, which adopts no special hobby for its exclusive program. Obviously, it is this type of club to which we must look

for extensive educational values; and in the organization and conduct of which we can find suggestion of a "boy science movement", or for the popularization of a real science interest, etc.

(b) The Organization Of The Club

The club each year adopts a constitution. It is not exactly within the sphere of this paper to dwell upon the technical point of constitution-framing, but a good deal is dependent upon the adoption of a document that will actually function. The constitution must be brief, simple and both written and adopted by the boys. At the first meeting of the club, it is well to point out the need for a set of rules, and then with the aid of the group to organize the material that that particular group wishes to put into its constitution, in the form of questions, thus:

1. What shall be the aim and purpose of our Science Club?
2. What shall be its name?
3. Membership:
   (a) Who can become a member?
   (b) What must a boy do to become a member?

4. Meetings:
   (a) When shall they be held?
   (b) Where?
   (c) How often?
   (d) Who shall call for special meetings?

5. Money:
   (a) Shall we pay dues?
   (b) How much?
   (c) Can we levy taxes?
   (d) How? How much?
   (e) For what shall the money be used?

6. Expelling members:
   (a) For what reason or reasons?

7. The Business Program:
   (a) How long shall it be?
   (b) What shall be the procedure?

8. The Science Program:
   (a) How many different activities shall the club have?
   (b) Who shall decide upon and arrange these programs?

9. Officers:
   (a) When shall elections take place?
   (b) How often?
   (c) What officers shall we have?
   (d) What shall be the duties of each officer?
   (e) How can an officer be impeached?
   (f) How can an officer resign?
   (g) Shall officers filling positions left vacant be appointed or elected? And how?

10. Any other regulations you think it important to put into the constitution.

The outline decided upon, a committee is appointed to present answers to the questions raised by the outline. In the meantime a set of temporary officers are elected. At the next meeting the constitution is discussed, altered and finally adopted by a majority vote. It is typewritten and pasted into the secretary's book. The chief value of the constitution is to create an "atmosphere". Often this procedure is the first of its kind that the boy has ever experienced. It appeals to him and makes for solidarity of the group.

The officers of the club usually consist of a president,a vice-president, a secretary, a treasurer, a sergeant-at-arms, a librarian, and two scouts. Their duties are those that usually devolve upon such officials. The sergeant-at-arms is custodian of apparatus—arranges seats—collects and distributes materials—and in general maintains order. The librarian is in charge of all books, pamphlets, magazine articles and pictures owned by or contributed to the club. He organizes a system by which members can draw books, etc., from the club library. The scouts discover and investigate interesting places to which the club can make excursions. The club, howerer, has the power of decision as to whether these excursions shall be arranged. The president and director arrange the science program for each week and the vice-president acts as recorder of the demonstration programs.

Dues are usually five cents a week and occasionally a tax of not more than ten cents is levied in order to purchase a special piece of apparatus or the club insignia or to pay for the awards and prizes.

A business meeting of no more than fifteen minutes precedes the main program, during which time the members act on the reports of the scouts, the librarian, or any committee which

may have been appointed, and passes on the applications for membership of new applicants.

Though qualification for membership varies with any particular group, it is usual to expect every member to prove his right to join by showing an ability to earn fifteen points of merit. (The Point System is described below). To remain a member in good standing it behooves a boy also to score at least fifteen points each month, in addition to his initiation points.

Sometimes when the club grows too large for efficient work, as in the case of the Speyer Science Club, it becomes necessary to recognize two types of membership. Grade A are the very active boys who give up practically all of their extracurricular time to science club activities. Grade B are the boys who because of the demands made upon them by athletics, other clubs, and home chores, cannot assume an equal share of the club's activities with boys of Grade A. They come to the meetings, are very much interested in its doings, and participate to the extent of their ability. Sufficient admission requirements and membership standards are imposed to avoid a "floating membership".

The success of the club is of course more dependent upon the director than upon any other one factor. The director should take no active part during meetings, except where it is necessary to carry the boys over what is to them an insurmountable difficulty. As was mentioned before, the director and the president confer upon and arrange each week's program. In all matters he should act as adviser. His frame of mind should be that of a man behind the scenes, who, having set the stage, stands by watching the performance, ever ready to step into a situation and set things right. The ability to do this properly comes with practice. It does not demand exceptional ability or personality. The writer has often absented himself from meetings, arranging for a student-teacher takes his place. The most necessary characteristics that the leader should possess is a familiarity with the interests of the boy, a well-organized program of activity, and ability to handle tools and to improvise apparatus, and a good knowledge of practical science. In other words, the qualities that go to make a good teacher of science are also essential for science club leadership. In some ways it is even easier to lead

a club than to teach. The club leader can with greater safety confess ignorance on some subjects and work together with his boys in the solution of a problem. A class-room situation is usually not as well adapted to such a procedure.

(c) THE PROGRAM OF ACTIVITIES

Next to efficient leadership, the successful club depends upon its program. In a sense, a well-organized program can make up for inexperience or poor leadership. There are in all five types of activities that merit description.

1. LECTURES

Boys like to imitate. They like to regard themselves a body of great scientists who are assembled to listen to and pass on great discoveries and inventions. With great seriousness they will introduce their speakers and sit back to listen critically to what is being presented. These lectures may be given by their own members, by former members who return with newer and richer experiences, or by adults. It is not very difficult to get science teachers, professors of science, or engineers to come before the club. They enjoy talking to youngsters. Occasionally the director presents a talk or a demonstration. More often the members themselves give these lectures, and stand the fire of dozens of questions which usually wind up their talks.

2. THE TRIP

The excursion is now a recognized form of instruction. As an activity of the club it presents quite a different problem. Excursions too often become a pleasant means of killing time. As a curricular activity it is subject to several difficulties. It cannot always be arranged to meet a classroom need at a crucial time. The teacher is handicapped by discipline problems, by limited time, by lack of information of the plant or factory visited. The engineer or person in charge is very seldom a teacher or one who can patiently answer the questions that boys will ask. The teacher must be ever conscious of a difinite

teaching unit and provide for reactions when the trip is over, which make the class too conscious of the fact of being taught. In the club, the boys must decide by a two-thirds vote whether to make the trip or not, and the dissenting one-third need not come. The result is an attitude which automatically provides for reactions that make the time spent educationally valuable. Those who have come to feel that excursions are always interesting and productive of enthusiasm, will surely revise their opinions after some experience with boys who are permitted to arrange their own excursions. The writer does not wish to go on record as being opposed to this means of instruction. The contrary is true. He does wish to point out the elements which make the trip successful. When the scouts interview the manager of a plant,they assume a responsibility which insures good order and respect for the company's property. Also, they seem to possess a strange faculty for discovering men who can talk to boys. Then, too, the club leader plays the role of visiter with the boys. And finally the original interest which motivated the trip calls forth lasting reactions that not only supply a fund of information but inspire thought. It is not at all uncommon to find a good many boys making a second and third trip to the same plant on their own hook, in order to learn more about some machine or process. It is to be noted that one of the secretary's duties is to write up the excursion in full detail. This account is read at the next meeting. No such account has ever gone uncorrected or unsupplemented. Often the compositions throughout the school for that particular month will abound in descriptions of the excursion.

3. SCHOOL ASSEMBLIES, EXHIBITIONS, BAZAARS, ETC.

The social life of any school is highly important. It produces that much-desired thing: "School spirit." There is no surer way for a teacher and his subject to become popular and respected than by entering into the social activity of the school. One of the activities of the Science Club is to arrange periodically for events to which the school at large can be invited. This has in the past taken many forms. Sometimes the school assembly period is devoted to an exhibition

of "science magic" or a demonstration of some boy inventions or the presenting of a playlet that has a science plot, etc. One or two experiences of this sort may be valuable in pointing out what science club leaders may expect in this phase of activity.

A play was to be presented at a Saturday afternoon gathering of boys, girls, teachers, and parents. The plot, written by a boy, was briefly as follows: The Science Club sergeant-at-arms catches a small fellow tampering with the wireless aerials belonging to the club. He hauls him before a meeting of the club, where he is put on trial. It develops that the culprit had been urged by mere curiosity and a desire to understand what the thing was. After some very wild suggestions by members as to punishments, one boy makes a plea for the offender's life, proposing that he be permitted to join the club where he could learn all about it. His eloquence wins the club over and they then proceed to initiate him "scientifically" into the club; after which the president ties the club insignia around his arm. When the "drama' commenced some of the leading actors became stage struck to the extent of forgetting their lines. Fortunately the movement of the plot, being of their own origin, was very clear in their minds. First one and then another they all abandoned their memorized lines and rose to the occasion spontaneously. In parts it was crude, but months of rehearsing could not have produced the spirit and genuineness of the acting. It was a great success.

On another occasion the club held a bazaar to raise money for the Red Cross. Samples of the club work were exhibited and people were urged to leave orders for any scientific toy that struck their fancy. The boys were carried away by their enthusiasm and obtained a great many orders for which they collected in advance. At the meeting that followed, they were confronted with the dilemma of either refunding some of the money or working for three weeks in order to fill the orders. The lesson in responsibility was a good one. They met their obligations.

In many other ways the Science Club can become a leader in the school's activities. The school newspaper, the school

library, and certain parts of the school plant can all be made to function in the club program.

4. THE WORK PERIOD

About every other week it is well to spend part or all of the program in actual work with tools and apparatus. This at once makes essential that there be not more than twelve or fifteen boys at a time. Ordinarily the work period can come once a week, the boys taking their turn in this activity. The purpose of this period is to give them an apportunity to try out their ideas and to experiment with their toys. During the demonstration programs to be described later, there are many things presented that stimulate them to "try out" and to "invent". The periods are designed to give outlet for these stimuli, and present a golden opportunity to direct a boy's thoughts into the proper channels. "Wild-cat" schemes can be quickly discouraged; information can be supplied; proper books put in his way, and in many other ways the boy can be helped to develop in scientific concepts and methods.

5. THE DEMONSTRATION PROGRAM

This is the most popular activity of the club next to the work period. The demonstrations center around a system of awards known as the Point System which is presented here in full. Each boy receives a copy.

Requirements For the Prize Offered By The Horace Mann Science Club

		Points
	(250 points which will be awarded according to the following list)	
1.	For constructing a piece of apparatus or toy	10
2.	For demonstrating a piece of apparatus or toy	10
3.	For performing an experiment	10
4.	For demonstrating a new Meccano or Erector Construction	10
5.	For demonstrating and explaining a Chemcraft experiment	10
6.	For discovering, demonstrating and explaining a new Chemcraft experiment	15
7.	For demonstrating and explaining a construction or experiment with an Electrical Set	10
8.	For demonstrating and explaining a new Electrical Set construction or experiment	15
9.	For making a great discovery or invention (so recognized by the club)	25 to 50
10.	For proposing an original idea in science	1

11. For working out that idea, or anyone else's idea in practice 5 to 50
12. For duplicating any of the experiments, devices, or phenomena described in any of the Popular Science Magazines......10
13. For rendering a report or lecture to the club on some important article in any of the magazines or newspapers..........5
14. For keeping a well-organized Science Scrap Book. (For every 50 important magazine or newspaper articles)..............10
15. For a collection of magazine diagrams and pictures on some important idea or topic in science.........................5
16. For entering any of the Popular Science Magazine competitions 5
17. For winning a prize 25
18. For being able to calculate the gas, water and electricity bills 5
19. For being able to regulate a clock 2
20. For being able to do simple wiring of bells and batteries....5
21. For being able to wire up a desk lamp 3
22. For being able to regulate and take care of a player piano or Victrola 2
23. For being able to replace a burnt-out electric socket 5
24. For being able to run a small electric motor................5
25. For being able to run a lantern slide machine 5
26. For being able to repair a bicycle, skates, window pulleys, window shades, etc. 5
27. For being able to take good pictures......................5
28. For being able to print and develop pictures...............10
29. For being able to take apart and put together again a phonograph, vacuum cleaner, or sewing machine...............10
30. For being able to measure a person's blood pressure..........5
31. For being able to measure humidity 5
32. For delivering a lecture before the club...................5
33. For taking a trip to some industrial plant and reporting to the club 5
34. For reading a book on science and reporting to the club....15
35. For reading a science story and telling it to the club........5
36. For being able to explain 10 of the phenomena listed on the club list 10
37. For being able to explain 10 of the things, mechanisms or processes listed on the club list 10
38. For knowing the names of 20 great scientists...............5
39. For knowing what great thing or things each is remembered for 5
40. For being able to give some important facts about the lives of 10 of them 5
41. For being an officer, scout, or librarian of the club..........5
42. For helping in the Science Shop 5
43. For helping some boy in working out his project............5
44. For excellence in Shop 5
45. For excellence in class work 5

When a boy wishes to claim points he fills out a slip of apper which he drops into the Program Box. The day before the meeting, the president takes out all these applications for numbers on the program and brings them to the director. Together they look them over, arranging them in the best order and making a list of equipment which will be necessary

It is understood that all special apparatus will be supplied by the demonstrators themselves, who are also expected to prepare and set up the apparatus they will need. The program consists of calling the boys up in the order arranged. Each number is followed by questions and discussion. One of the most interesting reactions that this activity produces is in connection with the presenting of so-called inventions. The inventor, after explaining and demonstrating his device must then meet a flood of questions. The originality of the work is sometimes contested; the feasibility of the scheme and its practical value criticized. He is required to test the device thoroughly and often to carry on these tests over a long period of time before he is granted the points. One of nearly one hundred "inventions" of this kind was a wiring scheme by means of which a person instead of knocking on a door could turn the knob and thus close a contact which would ring a bell. Certain features of the device were doubted by the members, who made the inventor install the device in his home to see how long it would stand usage. A committee was appointed to report on its practicability.

The club minutes are crowded with such instances. There is greater difficulty in preventing the standards from becoming so rigid that they discourage activity, than there is of allowing work of poor quality to pass. It has been the writer's experience that boys can be more severe with each other than can a teacher with a boy. One of the things the director must be ever-watchful for is the doing of an injustice to some boy by his fellows. In this connection it is well for the director to keep for himself the authority of granting or not granting the points; although it should be a common practice to call for a vote where there is assurance that a judgement thus arrived at will be fair.

The pressure of the group can be utilized by the director in various ways. In the case of a boy who is interested only in the "fireworks" of his Chemcraft Outfit, the club can very easily bring about one of two results, by insisting, each time he claims points for a new experiment, on a thorough explanation of what happens. Either he becomes entirely discouraged and ceases his Chemcraft activity or he is stimulated to master the "whys" and "wherefores" of what he is doing.

The minutes of the different clubs with which I have worked, show that in 67 cases of this kind, 42 of the boys appeared at a later meeting and presented an explanation of the experiment that satisfied both the director and the boys. In the case of 32 "inventions" that were given tests of practicability, 21 were eventually perfected. Of 212 cases where boys were "stumped" by questions involving knowledge which they did not possess, 40 tried to "bluff it out", 128 asked the director for help or resorted to books, and the rest were never again heard from on those particular questions. It is not new to those who have had imtimate experience with boys to say that the boys value more the respect and affection of their fellows than the reward in "points". It is also to be noted that, although a competitive system is set up in this scheme the competition is of the individual with himself; for each boy who scored 250 points for the year receives the same prize. On the average, eight or ten boys reach their goal each year.

In conclusion, it may be said that managing a successful Science Club depends upon four factors:

1. A club that is general in its interest and appeal rather than special.
2. A workable set of materials, which to a great extent can now be supplied by the toys the boys themselves possess.
3. A definite program of activities along the lines here described.
4. Intelligent leadership; the chief element of which is an ability to set the stage so that the boys will themselves carry out the program.

Furthermore, the chief role of the Science Club should be as a vehicle on which to carry promiscuous after-school activities into the schoolroom; where we may guide and control without losing that free, vital, purposeful urge to thought and to action that is so common to things our pupils do outside the classroom and often so sadly lacking in the things they do for us during school hours. And it may be that lessons taught us while running a club may reveal to us the secret of a classroom procedure that will make for greater efficiency.

Experiences with a Science Club

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Very soon after the club had been organized, the local schools observed *Fire Prevention Week.* The club, desiring to contribute something along this line began the study of a little play: *The Trial of Fire,* published in General Science Quarterly, March, 1921. The defendants in the trial are the various fire hazards personified: *Kerosene, Cigarette, Match, Electricity, Rubbish, Gas, Defective Chimney, Gasoline, Lightning, Bonfire, Spontaneous Combustion* and the arch criminal, *Carelessness.* The scene is a court room. Each defendant is examined by the Court and a verdict is finally rendered against Carelessness as the chief cause of fires in the United States. Carelessness is immediately sentenced by the Court to eternal banishment from America. Thirty pupils had parts in the play. The club discussed the play at several meetings, then rendered it as the program for one meeting. Later it was rendered by the club before the entire school at an Assembly. For this public rendition two features were added:—a stereopticon talk on *Fires in the United States* by a member of the club and a demonstration of spontaneous combustion by another member. This program was also rendered one evening before the Parent Teachers' Association of the school.

During the time the club was working on the play, the classes in science studied the units: "Combustion" and "The Chief Causes of Fires and their Prevention." Some of the best work of the year was done by these classes on the two units mentioned.

With this beginning, the club continued its regular weekly meetings, many applications for membership being filled as a direct result of the interest in the play. The program each week consisted largely of reports by various members on science articles in magazines and newspapers. Occasionally one member would take most of the time with a special demonstration or report. A short business session and the critics report formed a part of each program.

As a direct result of the interest in these discussions and reports, the number of science clippings brought to classes by pupils was practically doubled. Also the writer believes that there was much science reading done that was never reported to teacher or club.

In addition to these regular meetings, members of the club were detailed to assist in handling the motion picture machine and other mechanical features incident to the school motion picture exhibitions. This was also done in connection with the sterioptieon outfit. All electrical work incident to school plays and other special exercises was done by special committees from the club. The boys gave themselves to this line of service with the greatest enthusiasm and interest, often working for hours after school.

The last meeting of the club for the year was a public meeting. The entire school, including principal and faculty, was present. Also several visitors including one of the directors of science in the school system. The program consisted of a review of the work of the club during the school year by the president and a special demonstration of science visualized. Five reels of film were shown: *Introduction to the Study of Science, Why Water Should Be Boiled, Liquid Air, How Movies Move,* and *Wireless Telephony.* Before each reel was shown a member of the club gave a short talk by way of explanation. Four boys and a girl gave the talks. They were all to the point and prepared the audience for the several demonstrations.

The work of the club was done by the pupils under their own steam. The writer acted merely as an adviser. All regular and special meetings were presided over by the president. The arrangement of programs, the management of financial matters, the selection of pupils for various parts in connection with the special programs were handled by special committees. Many fine suggestions were made from time to time by various pupils. There was always perfect freedom of discussion followed by a judgment of the majority.

The boys and girls were always interested. The various preparations were for the most part very thorough. Any member showing a lack of interest or failing to report when his time came, was sharply censured by the body. At times the demonstrations and reports were exceptionally fine.

Judging from this particular experiment, the writer concludes

that science clubs for high school boys and girls are positively helpful. They decidedly supplement the work of the class-room by increasing the interest in science material, securing proper motivation, increasing the amount of supplementary reading, making the relation between pupil and teacher more democratic, increasing the self activity of the pupils and affording a larger opportunity for expression.

As experiments in education continue, as the Junior High School develops and is better standardized, and the reorganization of the Senior High School is more completely effected, we shall no doubt come to find that the club idea in connection with the work of these schools is the center around which all of our formal efforts of instruction must revolve to be effective. We shall probably find that it is nature's way. Until then, it will be wise for us to continue experimenting with this particular form of extra-curricular activity.

An Improvised Microprojector

RAY LAMBERT, Newcomerstown, Ohio

In many high schools funds for equipment are limited and the teacher must often make the best of what he finds rather than order equipment to his needs and liking. The writer has found it practical to construct a microprojector after this fashion. The instrument described below has been used in class work over an extended period, and good results secured.

This apparatus will do the work of twenty-five compound microscopes and in some ways, better. The image of the specimen is projected on the screen and all can see at once. The instructor may point out significant features in the specimen being studied, which is not possible with individual microscopes. Some loss in illumination is encountered, and the image on the screen is not quite as clear as when viewing the object directly through the microscope. However, the beginner does not have to learn to see, and does not encounter the eyestrain as is often the case with individual microscopes.

In describing the instrument as illustrated, it will be kept in mind that many details were determined by the odds and ends the writer happened to have at hand, and that different details will suggest themselves to the reader.

The apparatus is composed of the illuminating system, the cooling system, microscope and screen.

THE ILLUMINATING SYSTEM. The light is produced by a carbon arc operated on 110 volts A. C. The carbon rods are supported at right angles to each other. (1 and 2) The horizontal carbon is held to the upright rod (3) by an ordinary right angle clamp (4). The face of this clamp, on which the carbon rests, is lined with copper. A copper electrode from a small demonstration battery will do nicely. This may be bent

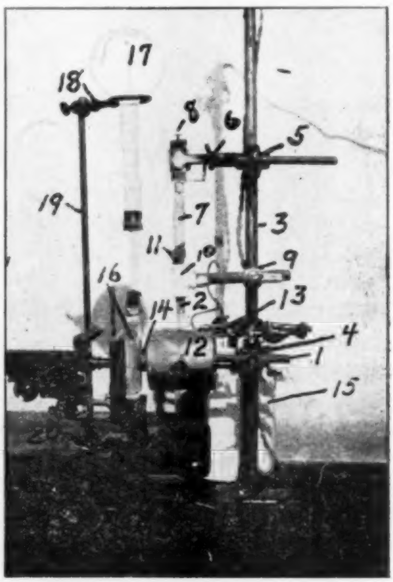

Fig. 1. An Improvised Microscope

lengthwise in the form of a "V" and the ends slit a short distance and fastened to the face of the right angle clamp. To one end a binding post may be attached and this bent back conveniently. Slip a piece of rubber, or a short piece of large rubber tubing, around the upright at the point the clamp is attached sa the carbon will be insulated from the support.

The vertical carbon (2) is supported by a clamp (6) held by a right angle clamp (5). In the jaws of the clamp (6) a set screw may be placed (8), which permits fine adjustment of the carbon. The upper carbon (2) does not come in contact with the clamp, but is supported by a short piece of rubber

tubing (7) slipped over the end of the carbon. To prevent too much play, the vertical carbon works through a gas pipe "T" connection (10) which is supported by a short piece of gas pipe held in a right angle clamp (9). This clamp should be insulated from the upright by a piece of rubber. One of the movable clamps from a demonstration battery will do nicely for the electrical connection to the upper carbon (11).

The light house (12) is made of a molasses can $3\frac{3}{4}$ inches long by $3\frac{3}{8}$ inches in diameter, and supported by a small clamp (13). This clamp attaches to a small horizontal rod and the rod is secured to the upright by a right angle clamp, so that the light house is subject to a slight vertical adjustment. A one inch hole is cut in the upper side of the can to accomodate the the upper carbon and the upper carbon projects through the lid of the can. Care should be taken that neither carbon touches the can.

The condensing lens (14) is supported in the end of the light house. This lens may be made of two ordinary tripod magnifiers. The top flange is soldered to the body of the magnifier, and may be removed by a gentle heat and discarded. Fasten two of the body tubes of the magnifiers together, using one of the rings to which the legs are attached. The lens separators of the magnifiers are soft metal and must be removed. Replace them with strips of copper with a width equal to the thickness of the separators and bent in a ring so as to fit inside the body tube. Place three of the lenses in the tube, and secure by screwing in the bushings on either side. Now cut a hole in the center of the bottom of the can which forms the light house, just large enough to insert the body of the magnifiers. The lens may now be held in place by screwing the other ring (which held the three legs) onto the end inside the can. The arc should be centrally located with reference to this lens, and will be satisfactory at a distance of $1\frac{1}{2}$ inches from the lens.

Cored carbons which give a flaming arc should be used. One half inch carbons are satisfactory. If the flaming arc is used the set screw (8) is not necessary, as the arc may be adjusted satisfactorily by moving the clamp (5) on the support. The lower carbon is adjusted by sliding in the clamp (4).

A rheostat must be used to control the current. This may be constructed from a gallon jar and two pieces of zinc or galvanized iron 3 inches wide and a little longer than the depth of

the jar. Bend a hook on one end of each piece of metal and let the strip hang inside the jar. To the hooks on the outside binding posts may be attached. Fill the jar with water and add a small handful of common salt. Do not add quite enough salt for the desired current at first, as the resistance decreases as the water heats. Connect one terminal of the light wire to the lower carbon and the other terminal to one side of the rheostat. Connect the other side of the rheostat to the upper carbon. A small switch and fuse (20 amp.) placed on the end of the table, beneath the top, will prove of great convenience.

THE COOLING SYSTEM. A cooling system will be found necessary, as without it injury will result to prepared slides, and the water in temporary slides will boil in a few minutes. To make this I used a small flat flask (16) ⅝ inch thick and a 500 c. c. Florence flask (17). The lower flask (16) should be provided with a two hole rubber stopper and the upper flask (17) with a three hole stopper. Three pieces of glass tubing are needed. One piece should extend from the bottom of the lower flask just through the stopper in the upper flask. The part of this tube in the lower flask should be bent to the side so that it will not obstruct the path of the light. A second tube should reach nearly to the top of the water in the upper flask and extend just through the stopper of the lower flask. The third tube connects the air space above the water in the upper flask with the outside. When in operation, there will be a continuous convection current downward through the first tube and upward through the second. The third tube serves for a safety valve. To fill, connect the stoppers and tubes with the lower flask, fill the Florence flask with water, pass the ring (18) over the neck and insert the stopper. If tap water is used, 2 or 3 c. c. of hydrochloric acid should be placed in the water to prevent precipitation when the water is heated. This system is supported by the ring stand (19).

If running water is available a stream of cold water may be forced through the lower flask, which would be a preferable arrangement. However, the writer has used the apparatus as described for over two hours continuously with good results.

THE MICROSCOPE. Any compound microscope may be used. It should have a joint in the stand so that the tube may be adjusted to the horizontal position easily. The one used is a Spencer, without substage condenser. The 16 or 32 mm. objective

should be used, and the eyepiece, x 5 or less. The ordinary eyepiece will do, but the achromatic projection eyepiece is to be preferred. For small magnification and large field remove the draw tube from the microscope, and use only the objective. The microscope may be clamped to a ring (20) and supported on the same stand as the cooling system. Two pieces of soft wood should be used so that the instrument may be held securely without marring the base. It is a wise precaution to remove the mirror.

THE SCREEN. The screen is an item of considerable importance. The writer has found a screen placed near the instrument the best. A screen of tracing cloth is used; and this is placed between the instrument and the class. Tracing cloth may be secured at any store handling drafting supplies. Any old picture frame 2 feet or more in diameter will serve the purpose of a support and this may be attached in any convenient way to a heavy tripod.

Tracing cloth expands with an increase in humidity, and special means are necessary to keep the screen from hanging in folds in damp weather. Cut the tracing cloth about 3 inches larger each way than the size of the screen desired and fold a ½ border of three thicknesses around the edge. Insert eyelets about 2 inches apart. Lay the cloth on the back of the frame and drive nails or tacks 2 inches apart around the screen so that when the cloth is centrally placed it will not touch the rows of nails by about ¼ inch. Secure ⅛ inch rubber bands, as long as possible, and thread the bands over the nails and through the eyelets, drawing the bands fairly tight but being careful not to tear the cloth. This will provide a uniform tension and the elasticity of the bands will compensate for the contraction and expansion of the tracing cloth.

The rough side of the tracing cloth should be used toward the instrument.

ADJUSTING. After the parts are assembled as described some care must be exercised in adjusting to secure desirable results.

The room should be darkened as well as possible with ordinary window blinds.

The magnification may be controlled, within certain limits, by the distance of the screen and the extension of the draw tube. When the screen is placed about 5 feet from the microscope, with the tube length at the maximum, using the x5 ocular

and 16 mm. objective, the magnification is approximately x 350, and the field on the screen about 2 feet in diameter.

The mounts are placed on the microscope stage as usual. If living specimens are used care should be taken not to include too much water under the cover glass as this will allow the covers to slide off.

The function of the illuminating system is to place a spot of intense light, about the size of a pin head, on the object to be projected. After the arc is struck the carbons should be adjusted so that the arc is about ¼ inch long, and the tip of the lower carbon barely behind the center line of the vertical carbon. The object must be centered in the focus of the condensing lens. To accomplish this, close the opening of the microscope diaphragm to the minimum, and raise or lower the ring (20) carrying the microscope till the image of the lower

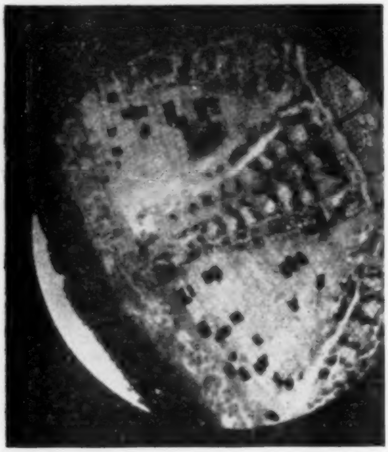

Fig. 2. A cross section of basswood stem as seen on the screen.

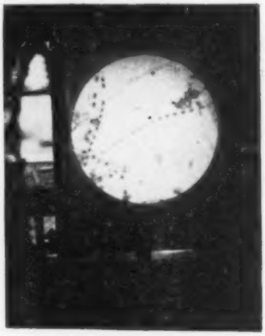

Fig. 3. A photograph of the screen with the projection of a fresh specimen of spirogyra. Conjugation and zygospores are shown. The field is about 22 inches in diameter.

carbon is centered in the diaphragm. Open the diaphragm, and carefully move the stand (19) backward and forward and perhaps a little to the side till the illumination is the maximum on the screen. In subsequent adjustments the light may be centered by moving the light house vertically. The slide carrying the specimen may be moved with the hand till the desired object is shown on the screen. Focusing the image is accomplished with the focusing screws of the microscope.

Bridges Old and New

RALPH MODJESKI, Member of the Franklin Institute.

From the beginning of history, and no doubt many centuries before, the means of transportation seem to have been considered the most important factor in the progress of civilization. In his history of the Great Highways of the Roman Empire, Bergier says:

"The Rulers of the various countries took great care to maintain the highways in such condition that the people could traverse them in security and convenience; the Kings of Sparta were especially charged to see to the good condition of the roads; Augustus, elected the curator of the great highways in the vicinity of Rome, engaged as helpers persons of pretorian dignity; in France, the King, in the early times, had reserved for himself the superintendence of the great highways; he delegated the carrying out of this supervision to his 'Grand Voyer'; Henry IV appointed as 'Grand Voyer' his Prime Minister Sully, that is, the man whom he esteemed most."

The existing records of ancient bridges, meagre as they are, seem to indicate that men were building bridges at least sixty centuries ago.

We do not know exactly when one type of bridge followed another; but it is certain that all our modern types, such as girder, arch, suspension, and even cantilever, were used in primitive shape in those very ancient times. We have still existing examples of the beam or girder bridge; monuments proving age-old knowledge of a rudimentary arch; we have records of the early use of the suspension type; and records of the cantilever combined with the girder type connecting-span almost challenging our credulity.

The first bridge built by man no doubt was of the kind easiest to build—possibly a tree thrown across a stream or ravine. Thus unwittingly, the man invented the girder. But as early as 4000 B. C., notable progress must have been achieved in the art of bridge-building, for, according to Herodotus, Menes,

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1 Presented at a Meeting of the Franklin Institute May 17, 1922. Reprinted by courtesy of the Franklin Institute, from the September issue of the Journal of the Franklin Institute.

one of the first kings of Egypt, then had a bridge constructed over a branch of the Nile and though we have no details of this early structure it must have consisted of at least several girders or even arches.

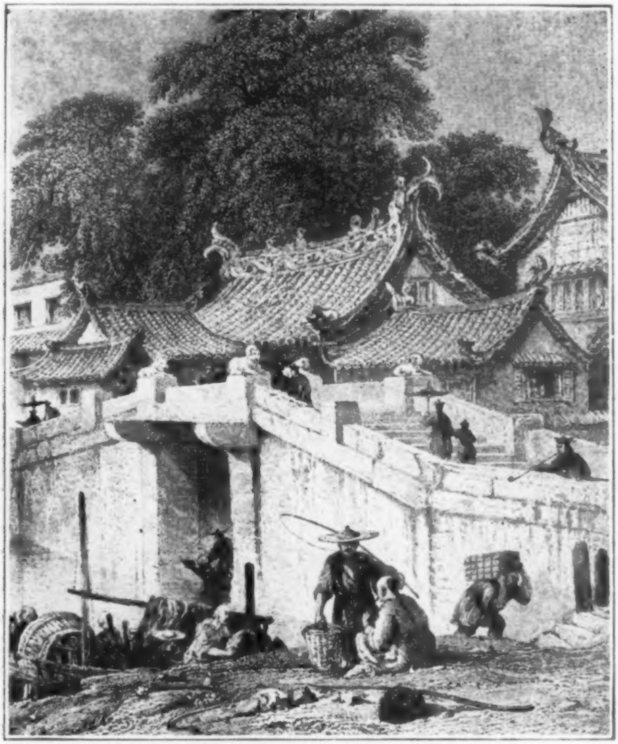

Fig 1. Slab bridge at Chapoo, China

We have mention in history of Lake Villages in the Bronze Age, or about 1400 to 1200 B. C. They consisted of many bridges built of wood leading to a central group of dwellings. There are remains of a Lake Village in Glastonburg in the British Isles.

LINTEL AND SLAB BRIDGES

Among the oldest monuments we have of bridge construction are the so-called lintel and slab bridges. The former consisted

of oblong stones placed vertically in the stream and spanned by long, flat, narrow stones or lintels. Sometimes lintels have been placed on piers built of smaller stones. There are some examples of these ancient bridges in the Valley of Wycoller in Lancashire, England, dating back to the Bronze Age. The so-called slab bridges differed from the lintel bridges in that large

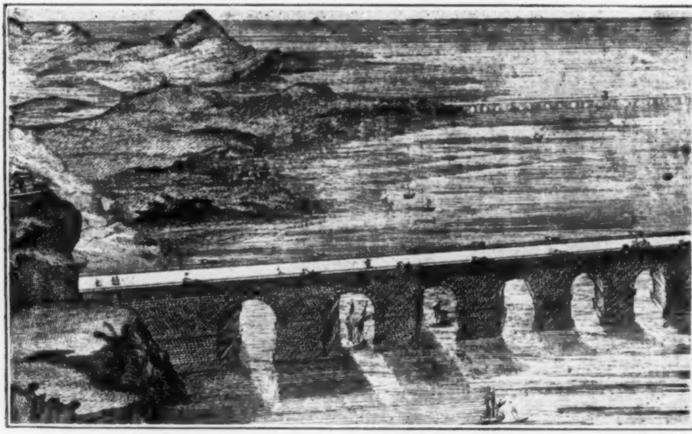

Fig. 2. Bridge at Fo-Cheu, China.

slabs of stone were used instead of narrow ones. Some examples still exist in the Dartmoor region, England. But it is China, probably, who has built more slab bridges than all other countries combined. There, as in other countries, a single-span bridge—arch or beam—was the first form constructed. Such is the type of the bridge at Chapoo which is very ancient though information even as to its approximate age has not been found. It is a bridge for pedestrians only, built of stone slab beams resting on stone abutments; most beautifully proportioned as a whole and in all its parts (Fig. 1). There are many similar single-span bridges in China of more or less ancient origin, all of them showing the extraordinary ability and workmanship of their builders.

CHINESE ARCH BRIDGES

Later, with the advance of civilization, bridges of greater length — of more spans — made their appearance. Emiland

Gauthey speaks of a bridge, said to be still in existence, at Loyang, in the province of Fo-Kien, which has three hundred spans; it took eighteen years to built it, and five thousand men were employed. It is probably a slab bridge. The slabs are said to be of huge dimensions: about 9 feet by 15 feet by 100 feet. Gauthey further expresses a doubt as to the correctness of these dimensions and according to Pingeron they are only

Fig. 3. Bridge at Srinegar, India.

about 4½ feet by 4½ feet by 45 feet. Even then, Gauthey says: "It is a wonderful achievement—more than four and a half times longer than the Pont Saint Esprit." Taking the dimensions given by Pingeron, the bridge is about 14,500 feet long. It is ornamented by large marble lions, a decoration which has often been used in the old Chinese bridges. It is again Gauthey who describes a bridge of 24,000 feet in length in the province of Fo-Cheu, over the river Min. It is said to have a hundred arches, all semi-circular, of an average opening of 128 feet, and a width of 60 feet. The piers, therefore, are very broad, and the height is 120 feet. This bridge also is ornamented with huge lions in black marble cut out of blocks twenty-two feet long. It was said of this bridge that vessels could pass under the arches with all sails set (Fig. 2).

PRIMITIVE CANTILEVER BRIDGES

However it may stand between the wooden and the stone span as to priority in history, there came a time when the two materials were combined in the construction of bridges.

The Lake Village bridges were apparently all of wood while the lintel and slab bridges were of stone; both these types, as said before, dating back to the Bronze Age.

But Violet le Duc found in Savoy (France) a primeval bridge built of logs laid criss-cross, each layer of logs projecting beyond the one below and the crib thus formed filled with rock. These cribs then had the shape of brackets or cantilever arms projecting over the stream. The gap between them was bridged with timber. Here we have a prototype of the cantilever bridge. Criss-cross bridges of several spans may still be found in use in Kashmir, India, and in other eastern countries.

Fig. 4. Bridge at Srinegar, India.

The bridges at Srinegar, India, built of deodar logs, are typical examples of this kind of construction; they have several piers, each corbeling towards its neighbors, the remaining spaces being bridged over by long beams (Figs. 3 and 4).

One of these bridges has houses or shops built closely side by side over the whole length of it. This idea has been repeated often in European bridges; as in the well-known old London Bridge, the Ponte Vecchio in Florence, and in certain old Swiss bridges. The merchants evidently selected a location where passing their shops was unavoidable.

A still nearer approach to the true cantilever is seen in the primitive form in the bridge near Darjeeling, in the Himalaya Mountains, N. W. India (Fig. 5).

LEGENDARY BRIDGES

Herodotus mentions that a magnificent bridge was built over the Euphrates at Babylon. This bridge is said to have had stone piers connected by planking which was removed at night.

Fig. 5. Bridge near Darjeeling India.

As building foundations under water was not known, the river was diverted during the construction of the piers. Diodorus ascribes the bridge to Semiramis, which would place it nearly 800 B.C. There is an historical mention of large pontoon bridges built by Darius on the Danube about 500 B.C. and somewhat later one by Xerxes on the Hellespont, but unfortunately no details of the construction of these various structures have reached us.

FIRST ROMAN BRIDGES

To the Romans is due the greatest progress in bridge-building. They did not hesitate to cross the broadest streams in their march to conquest and did so by means of various types of structure wooden trestles, wooden arches on stone piers, or with purely stone arches.

The Roman aqueducts, built about 600 B.C. consist of masonry arches, but the opening of the arches never exceeded 20 feet.

The first Roman bridge of which we know was built of timber in 620 B. C., at the foot of the Aventino Mountain. It was

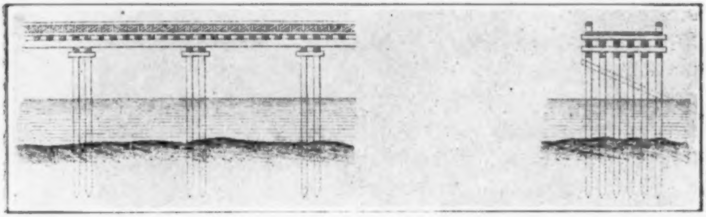

Fig. 6. Pons Sublicius.

called Pons Sublicius. There is some controversy. as to its exact location on the Tiber. It was built entirely of wood, not

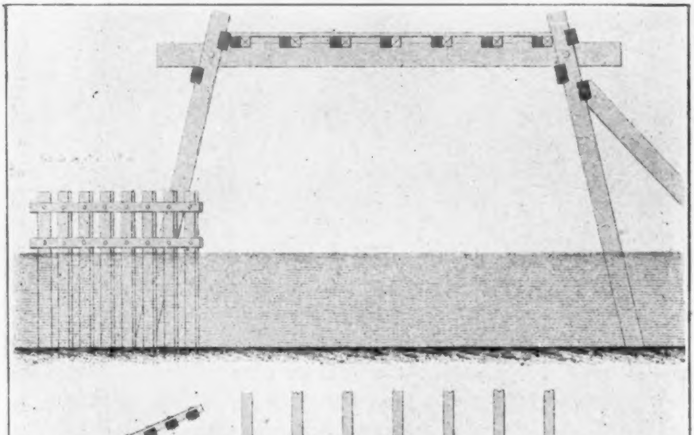

Fig. 7. Bridge over the Rhine, built by Caesar.

unlike our modern trestles (Fig. 6). According to Denis of Halicarnassus, this bridge was built at the expense and by

the efforts of the first re'igious heads, whence their name "Pontifices." It was destroyed in 507 B. C., while Horatius Cocles was defending its passage. Pliny says that in rebuilding it care was taken not to use any iron or nails, to facilitate its destruction in future wars.

History speaks of a timber bridge built over the Rhine by Caesar in 55 B.C. It was temporary and simple, but said to be

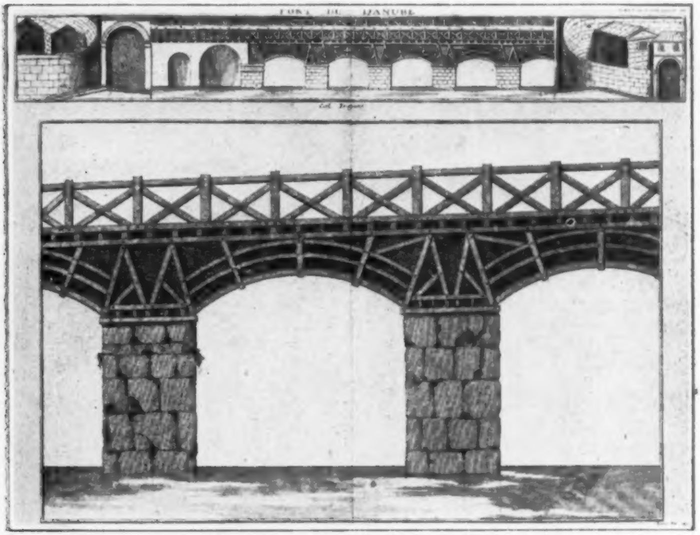

Fig. 8. Trajan's Bridge over the Danube.

very solid. It was from 2000 to 2300 feet in length, and is said to have been built in ten days (Fig. 7).

Trajan was a great bridge builder. His bridge over the Danube just below the Iron Gate was in his time a gigantic undertaking. It was built probably about 104 A.D. (Fig. 8). Its engineer was Apollodorus of Damascus, who also built the Trajan Column in Rome, on which there is a bas-relief of the bridge apparently distorted by the sculptor. The ancient historian, Dion Cassius, states that the bridge had twenty piers of hewn stone, 150 feet high and 60 feet wide, with openings between them of 170 feet. The bas-relief gives clear information that the stone piers were connected by wooden arches. There are still thirteen piers visible out of the twenty. The length of

this remarkable structure is said to have been 3900 feet (Murray's Handbook), although other sources give this length as nearer 3000 feet. It is believed that the foundations for the piers were obtained by sinking caissons.

FIRST STONE ARCHES

The true stone arch came to be used only after other forms

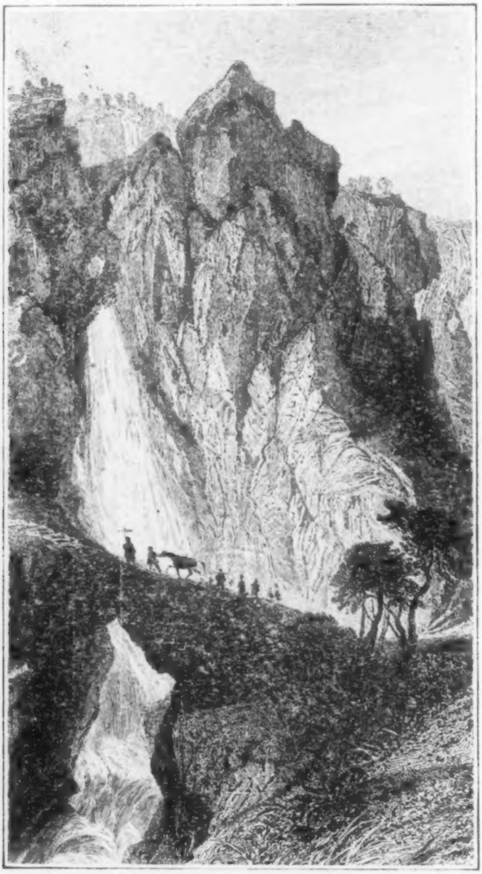

Fig. 9. Natural bridge at Han-tsuen, China.

of construction resembling the arch had been tried. In fact, there seems to have been a definite process of evolution and its different stages are quite marked. No doubt the first idea of

an arch came to man from some natural rock formations of which there are many throughout the world. One of the most remarkable instances, and where this natural bridge is used as a crossing, is at Han-tseuen, in the Province of Kiang-nan, China (Fig. 9).

But, being monoliths, these natural arches gave no indication

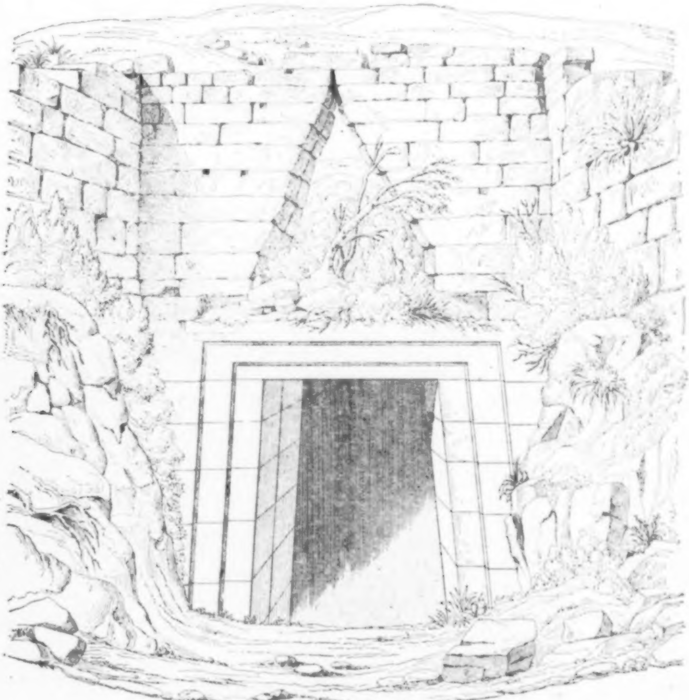

Fig. 10. Agomemmon's Grave at Mycenæ.

of how to imitate them with smaller stones, so that the arrangement of joints became the subject of experiment through many centuries.

The Egyptians and the Greeks built arches in very ancient monuments, but they were not true arches and had only very small openings. In Greece, especially, the first arches were built of stones laid in horizontal courses, each course projecting beyond the one below. This was first done cautiously, so that

the top courses did not meet as in the later constructions but the remaining space was bridged by a lintel. An example of this endeavor to approach an arch is seen in the entrance to the commonly called Agamemnon's grave at Mycenae (Fig. 10). The lintel still exists but the horizontal courses supporting it approach each other as they rise. The upper triangular open-

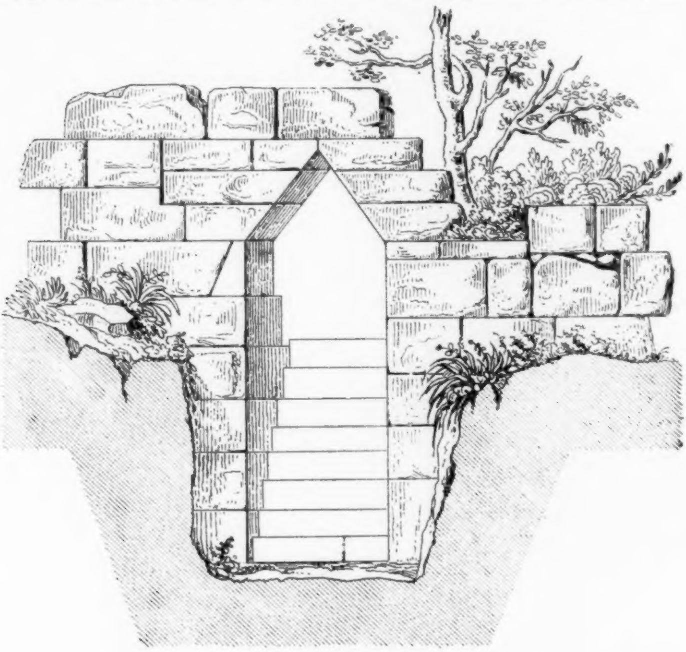

Fig. 11. Entrance to theatre at Meseina.

ing shown in the cut must have been filled by some ornamental slab which was subsequently removed. It is even possible that this was done to relieve the weight on the lintel. In the entrance to the theatre at Messina, Greece, the lintel is omitted and the approach to the arch becomes closer (Fig. 11).

But the real prototype of the true arch, where the stability depends entirely on abutment re istance to horizontal thrust, is found in the entrance to the great pyramid at Memphis (Fig. 12); also in the roof of a granite grotto of cyclopean masonry, situated on the island of Delos near the top of the Acropolis (Fig. 13).

ROMAN STONE ARCH BRIDGES AND AQUEDUCTS

Gauthey says that Pons Salaro over the Treverone in Rome

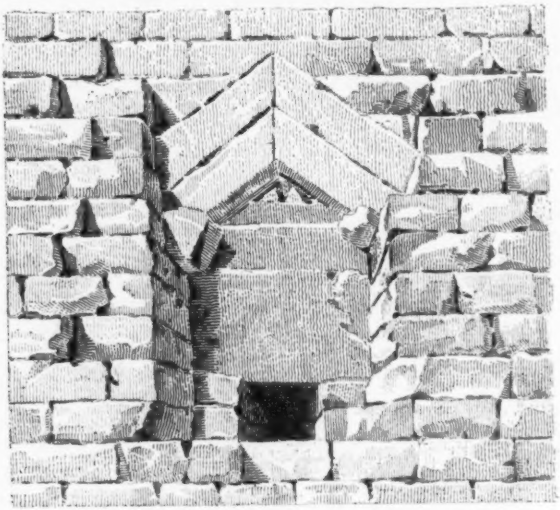

Fig. 12. Entrance to the great Pyramid at Memphis

was built 600 years B.C. It is not known if it was built of stone at that time or merely of wood and replaced by stone

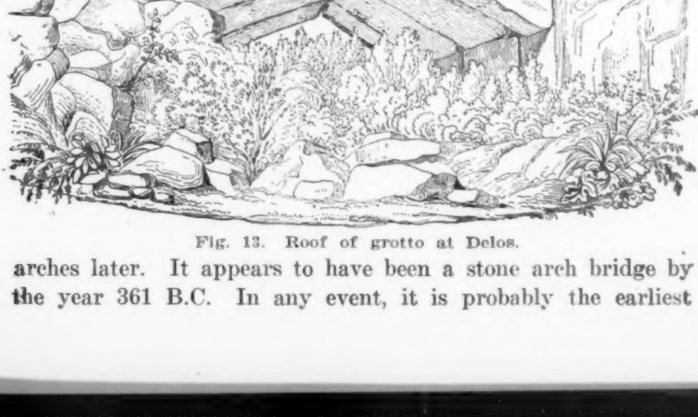

Fig. 13. Roof of grotto at Delos.

arches later. It appears to have been a stone arch bridge by the year 361 B.C. In any event, it is probably the earliest

Roman stone arch bridge. It consisted of five arches of openings varying from 22 to 69 feet. Pons Palatinus, built in 179 B.C., is now known as Ponte Rotto. One arch is still in existence.

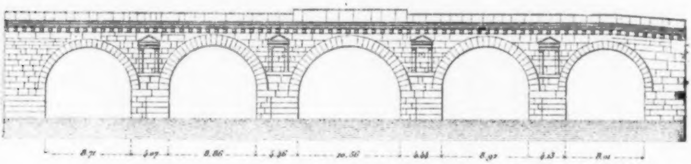

Fig. 14. Ponte Rimini, Italy.

The Romans built many stone arch bridges during the beginning of the Christian era, many of which have been partly or wholly preserved, and some of which are even still in use. The

Fig. 15. Pons Aelius, now Saint Ange, Italy.

Rimini Bridge (Fig. 14), built under Augustus, is perfectly preserved. The Pons Aelius, now Saint Ange, built about 130 A.D.

Fig. 16. Bridge at Narni, Italy.

by Emperor Hadrian, has been repaired and ornamented with statues, but is entirely preserved (Fig. 15).

Only one arch of the bridge at Narni, Italy, built by Augustus Caesar, remains standing, where originally there were four, of white marble, elaborately designed (Fig. 16).

The aqueduct of Gard in France, built by Agrippa at the beginning of the Christian era to bring water to the city of

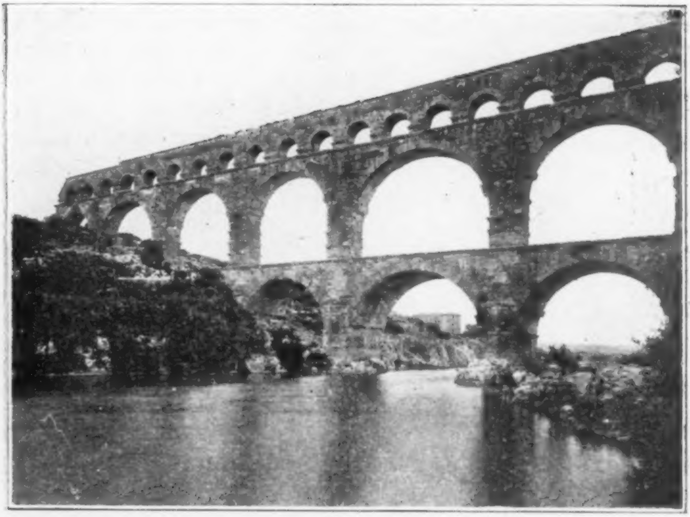

Fig. 17. The aqueduct of Gard, France.

Fig. 18. Alcantara Bridge, Spain.

Nimes from a distance of about 24 miles, was built entirely of cut stone, 158 feet above the surface of the water. No cement or mortar was used except in the uppermost arches and as a lining in the water-carrying trough. This bridge of Gard (aside from that of Metz) is the only one which remains in France of those constructed before the twelfth century, all others having been destroyed by the invading Barbaric hordes of that period. Even this structure did not escape unharmed, both its ends having been destroyed (Fig. 17).

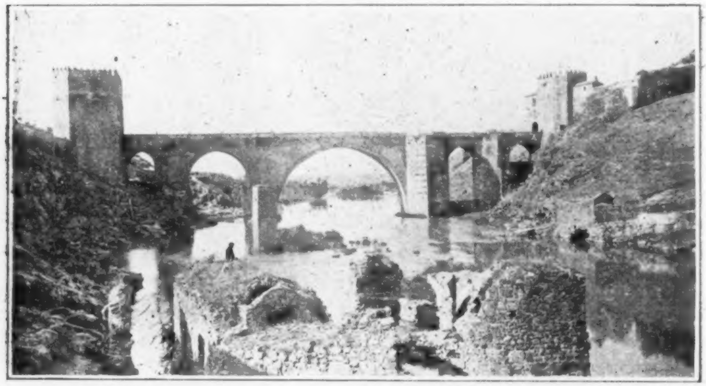

Fig. 19. St Martin Bridge, Spain.

Of the Roman bridges still preserved in Spain, we should mention the Alcantara and the St. Martin bridges. Both of these are due to Trajan and both are very bold and remarkable structures (Figs. 18 and 19).

The gigantic aqueduct of Metz, of which ruins still remain, is another exemple of Roman enterprise, energy and ability in building great structures. This aqueduct formed a part of a very elaborate water supply system. The water of the streams was gathered into reservoirs from which it flowed through stone-lined tunnels, "so spacious that a man could walk through them with very little stooping," and crossed the Moselle on this viaduct. From there the water flowed through similar tunnels into the baths and into the Naumachia (Fig. 20).

Colmenares in his history of Segovia says, that the Roman aqueduct at Segovia may be cited as one of the most marvellous works left us by antiquity. Montfaucon wrote in 1722 that one

hundred fifty-nine arches were still standing, all of large stones without cement. The total height was 102 feet with a double row of arches, one over the other.

Another Roman stone aqueduct is situated in Tarragone, Spain, and is very well preserved (Fig. 21).

The Romans used also brick and concrete in the construction of their aqueducts. Several ruins of this method of construct-

Fig. 21. Roman aqueduct at Tarragone, Spain.

ion still may be seen in Italy. The one named after Nero was built of brick and was of very fine workmanship. The Alexandrine viaduct was built of brick over concrete.[1]

MEDIÆVAL BRIDGES

The Middle Ages have left us a number of bridges in various states of preservation. They are almost entirely of stone construction—arches and piers. And almost all the bridges of the twelfth and thirteenth centuries were very narrow and with very steep approach grades. Often the entire absence of parapets made it very dangerous to cross them at night. There is a feeling of difference between the points of view of the builders of the Roman times and of the Middle Ages, in spite of a com-

1 W. Shaw Sparrow: "Book of Bridges."

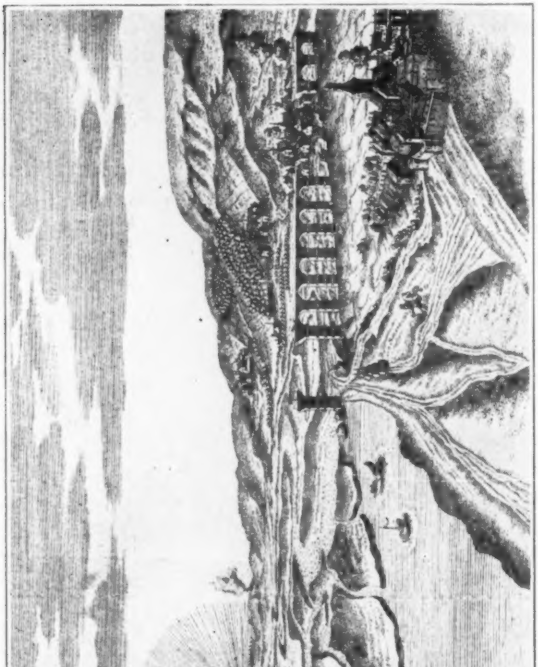

Fig. 20. Roman aqueduct at Metz.

Fig. 22. Pont du Saint Esprit.

mon quality of simplicity. The old Roman bridges seem to have built with every line, mass and form shaped directly to meet the requirements of utility; with the result that no line or form could be questioned by the eye. But in the mediaeval bridges good proportions often are hurt by a conforming to mathematical orderliness; or dignity and simplicity seem more a superficial expression of taste on the part of the monastic orders that built them.

One of the most remarkable works of those times was the Pont d'Avignon in France, built in 1178 by St. Benezet. There were twenty-one arches though to-day only four remain. The total length of the bridge was 2000 feet and the principal arches had an opening of 108 feet. St. Benezet gave his arches the form approaching an ellipse with its long axis placed vertically. This was quite a bold departure from the arches of the Romans who seemed to have used circular curves exclusively.

Over the Rhone we have the Saint Esprit Bridge, which was begun in 1265. It is said to be one of the longest stone bridges in the world and was very solidly built and strong. Its building lasted forty-five years, being finished in 1309. It was at first planned only for pedestrians and cattle, but at the beginning of the last century it was placed in service for vehicles (Fig. 22).

The Pont de la Guillotiere, also in France, is in use at present. It has been widened lately by the addition of steel arches on both sides of the bridge, resting on the old piers.

Bridges are and have been at all times the most vulnerable part of a nation's transportation system. In case of war they are the first points to be attacked and destroyed. This was plainly recognized in the Middle Ages, for most of the bridges of that time were fortified. Some conspicuous examples of such structures have been preserved. The Pont des Trous in Tournai, Belgium, for example, is protected at each end by a large tower and the parapets are high like fortress walls and provided with nine arrow-slits. Recently this bridge was again the scene of bitter struggle, when the Prussians forced a passage there (Fig. 23).

At Valentre, France, we have another example of the fortified bridge. It was built in the thirteenth century and in design has much of the grace and simplicity of the older bridges. Each of the three towers forms a vaulted passage, which could be closed by barricades when necessary. This bridge was built of small-

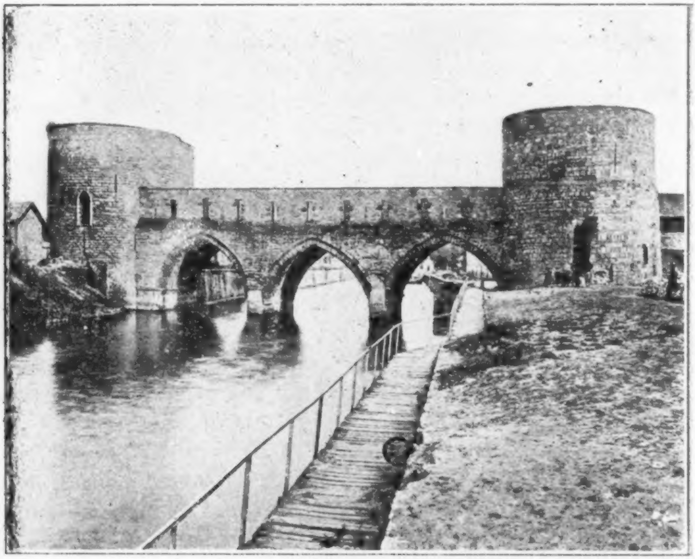

Fig. 23. Pont des Trous at Tournai.

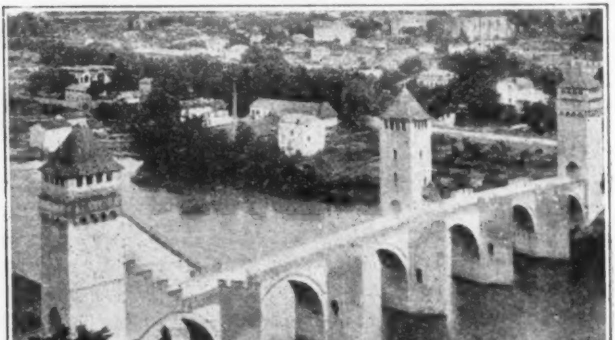

Fig. 24. Port Valentre. France.

sized stones cemented together with a mortar which has become very hard (Fig. 24).

The bridge at Orthez in the French Pyrenees, built in the twelfth century, has only one tall tower. The weight of this tower has been utilized, with Roman directness, to resist the horizontal thrust of the larger arch, being placed over the pier between the two small arches and the large one. History connects it with the battle of February, 1814, when Wellington defeated the French near Toulouse (Fig. 25.)[2]

Fig. 25. Pont d'Orthez, France.

The bridge called Castelvecchio, at Verona, is a strange example of the fortified bridges, its distinctive battlements forming the parapets giving it an outline of unique picturesqueness. It was built in 1356. The base of the piers is built of white and red marble for about 12 feet above the ordinary water level. The arch wings are of limestone and the rest of brick. It is said that some of the marble was taken from Roman ruins (Fig. 26).

One of the most interesting bridges, due partly to the Romans and partly to the Middle Ages, is the Devil's Bridge at Martorell, Spain. It would seem that the bases of the piers, the

2 Figs. 24, 25, and 26 have been taken from Paul Sejourne's "Grandes Voutes."

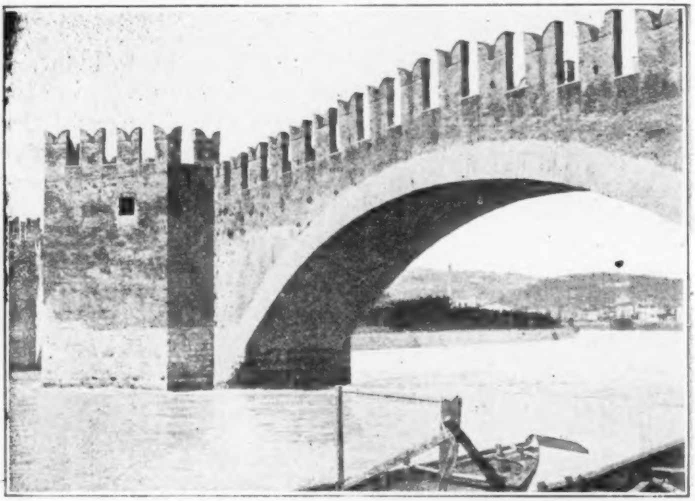

Fig. 26. Castelvecchio Bridge, Verona.

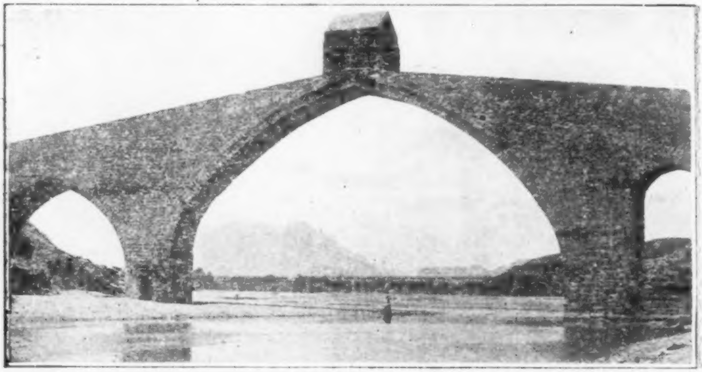

Fig. 27. Devil's Bridge at Martorell.

arches and spandril walls, which are of small stones, date from the Middle Ages. Some of its arches have a curious Gothic form and the top of the large arch, which has an opening of 145 feet, is held down by a chappel. The large arch has two superposed abutments and the triumphal arch (not shown on cut), which are of large cut-stone masonry, are of Roman origin, while the arch-rings and a third one near the upper part of the arch, which diverges from the other two at a point about one-third

down from the summit and loses itself in the spandril walls. This method of superposed arch-rings without any interlocking between them is very characteristic of arches of the Middle Ages (Fig. 27).

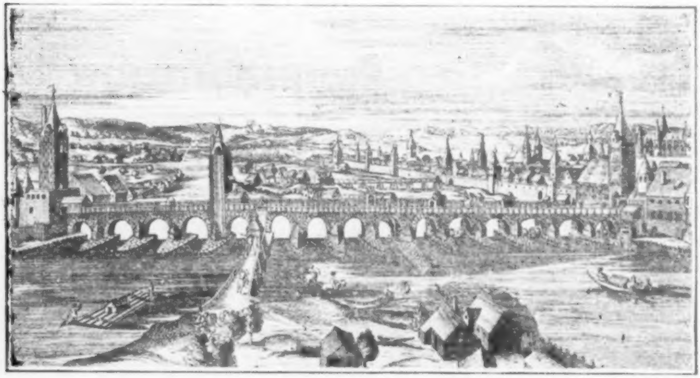

Fig 28. Regensburg Bridge, Austria.

LARGE STONE-ARCH BRIDGES OF THE XVIITH AND XVIIITH CENTURY

Of the later bridges, one built in Regensburg, Austria, shows how little confidence the engineers had in the foundations, for

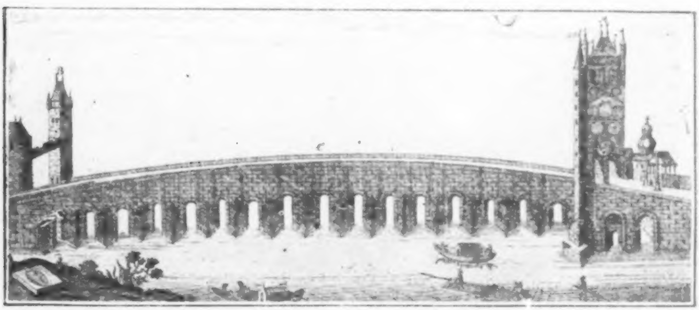

Fig. 29. Bridge at Prag.

they protected the piers by large cribs filled with stone, which cut off the greater portion of the waterway (Fig. 28).

The bridge at Prag was begun in 1638 but not finished until the beginning of the eighteenth century. At the time it was built it was one of the four largest bridges in existence. Also

it was considered the widest one; its width between parapets being over 35 feet (Figs. 29 and 30). [3]

LONG-SPAN WOODEN BRIDGES OF THE XVIIITH CENTURY

About one hundred years after the Prag bridge was built wood made a sudden reappearance as bridge material, this time for spans of considerable length. Two village carpenters, Jean and Ulrich Grubenmann, born at Teufen, Switzerland, began to build long-span bridges of timber, employing a most ingenious system of their own invention. In 1755 Ulrich began his bridge over the Rhine in Schaffhausen and completed it

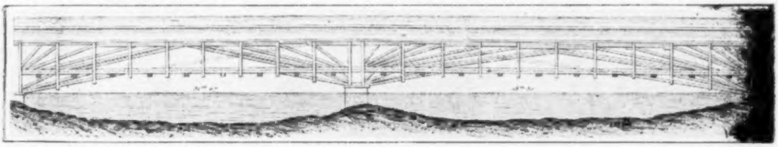

Fig. 31. Bridge at Schaffhausen, Switzerland

three years later. It consisted of two spans of a total length of 364 feet with a width of roadway of 18 feet. It was supported on masonry piers (Fig. 31). The bridge was covered with a roof—a practice generally and properly followed in most timber highway bridges of those times. At the same time Jean built a similar bridge at Reichenau with a span of 240 feet and a little later both brothers built the Wittingen Bridge near Baden with a single span of three hundred and ninety feet (Fig. 32). The length of this span is given by some authorities as only 366 feet. Even then it was an astounding achievement considering that calculations of stresses or even the strength of timber in compression were entirely unknown. Since the Grubenmann brothers, wooden bridge-building has made no progress in Europe. It was further developed in the United States but, as will be seen later, on entirely different lines.

SUSPENSION BRIDGES

The suspension bridge is probably as old as other types and may have been originally inspired by vines hanging over a

3 Fig 30 is added to correct the impression which Fig. 29 may give that the bride was built on a vertical curve. While the picture is not as elaborate it is probably more accurate.

Fig. 30. Bridge at Prag.

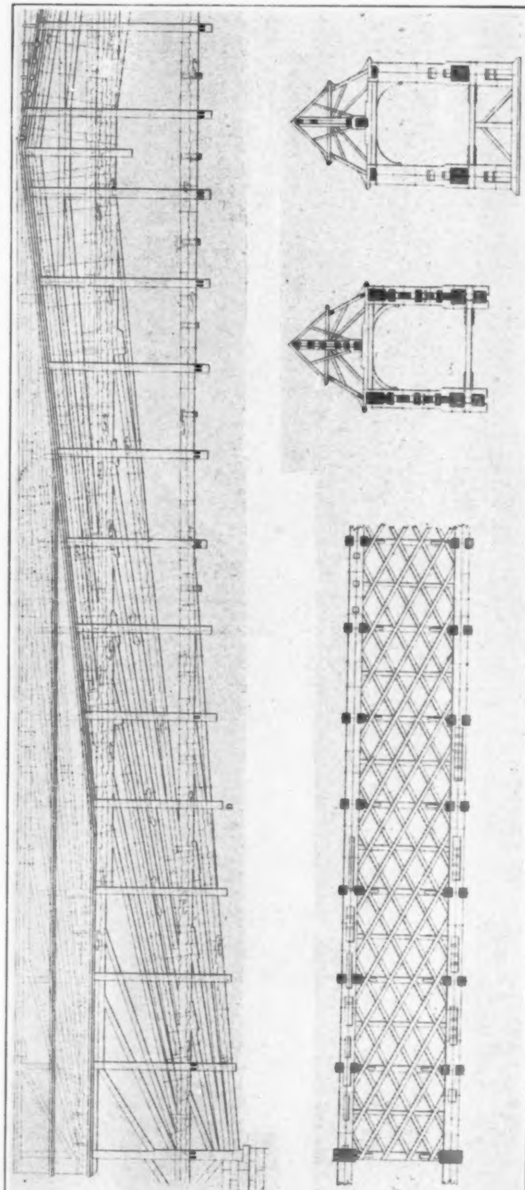

Fig. 32. Bridge at Wittingen.

Fig. 33. Foot-bridge near Lake Izabal, Guatemala.

Fig. 34. Foot-bridge in Sikkim Valley, India.

A cane bridge in Sikkim Valley, India, is another example of this simple and primitive construction (Fig. 34).
stream. There is a suspension foot-bridge in Guatemala near Lake Izabal which vividly suggests this origin (Fig. 33).

The first suspension bridge cables were either of wires or ropes and the floor followed closely the curve of suspension.

Leopold speaks of a very old suspension bridge in China built

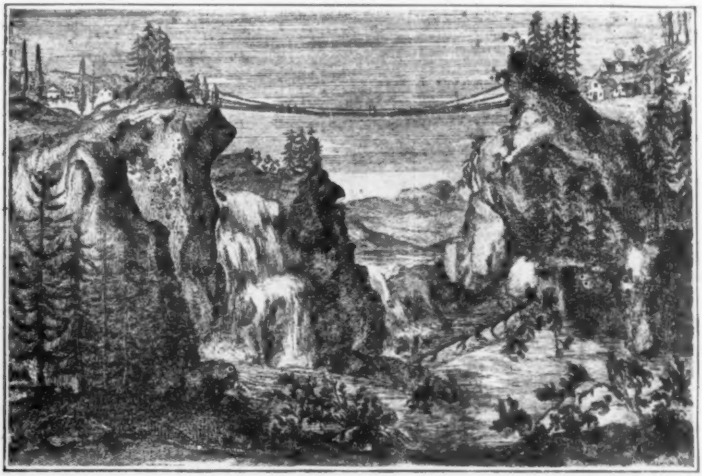

Fig. 35. Suspension bridge in China.

from rock to rock, consisting of twenty very heavy iron chains covered with planks. Here the rocks acted both as towers and as anchorages (Fig. 35).

Not until the end of the eighteenth century was the idea carried out of suspending a horizontal roadway from the cables, although a very rare and ancient work, entitled "Machinae novae Fausti Verantii Siceni," illustrates the principle of the Faustus Verantius Bridge, calling it "portable and convenient for the armies" (Fig. 36).

In England in 1819 Sir Samuel Brown built a suspension bridge over the Tweed which had a span of 449 feet. In 1826 Telford completed his famous suspension bridge over the Menai Straits. It is still in very good condition. The span is about 580 feet and is hung from iron chain cables (Fig. 37)

The Americans seem to have preceded the Englishmen in building suspension bridges with chain cables of long spans. In

1808 there were over forty suspension bridges in the United States constructed under the Finley system. Engineer James Finley employed cables made of long chain links, and later, of iron bars.

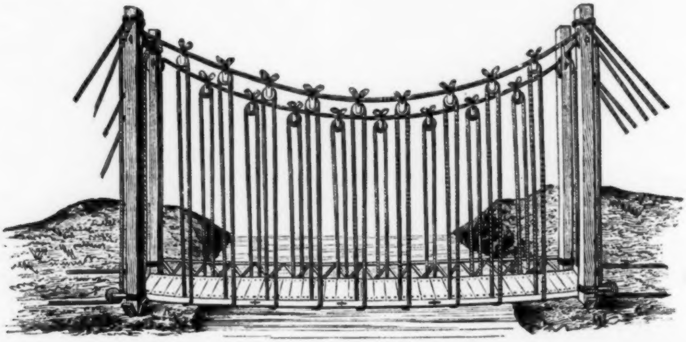

Fig. 36. Pons Faustus Verantius.

The first wire-cable suspension bridge seems to have been one built over the Schuylkill River in 1815. It was a foot-bridge only,of 400 feet span. Since then the building of suspension

Fig. 37. Bridge over the Menai Straits.

bridges has made great progress and now they are recognized as the best-known form of construction for very long spans. Everyone is familiar with the New York bridges which are the longest suspension spans in the world.

DEVELOPMENT OF METAL BRIDGES

Iron was known in China, India, and Egypt for a long time. Steel also was known about 500 B.C. but was not made in Europe until the thirteenth century. Cast iron, strange to say, came still later, but was the first to be used in metal bridges. Abraham Darby is credited with having built the first cast-iron bridge. In 1779 he completed the well-known bridge at Coobrookdale, England. It is an arch of 50 feet rise and 100 feet opening. This was followed by other cast-iron bridges in England as well as in France.

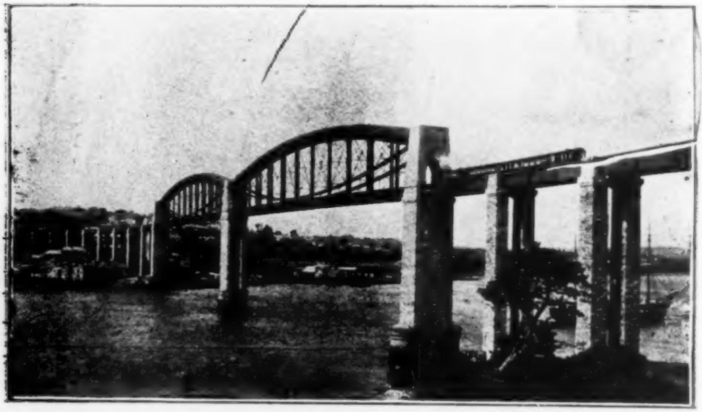

Fig. 38. Saltash Bridge, Plymouth.

In 1844 wrought iron was first used in bridge work in the form of girders. In 1850 Stephenson built the tubular bridge over Menai Straits. This was followed rapidly by other tubular bridges in England and Canada, some of their designs being more original than efficient. Most of them have stood well, however, probably because of large excess of material used. One of the most remarkable examples is the Saltash Bridge built by Brunel in 1858. It is a large, single, curved tube placed above the roadway and connected with curved bottom chords. The tube was made of elliptical section and its width was determined by the width of the roadway below. The two main spans are each 456 feet long. The bridge is said to be still in use (Fig. 38).

Experiments with tubular designs were soon followed by lattice girders and steel arches. In France lattice girders continuous over three or more supports were at first quite popular. Later, simple spans with curved top chord seemed to find more favor. A very neat design is that of a bridge near Dinan, France (Fig. 39).

Fig. 39. Bridge near Dinan, France.

Probably the most decorative designs in steel were obtained by using arches. A beautiful example of such construction is seen in the Eads Bridge at St. Louis; another good example is the bridge at Coblenz, Germany (Fig. 40).

THE FORTH BRIDGE AND THE QUEBEC BRIDGE

Then came the gigantic work of the Forth Bridge with 1790 feet spans (Fig. 41) and, lately, that of the Quebec Bridge with an 1800-feet span.

These two bridges have the longest spans in existence and are both of the cantilever system. Yet the methods followed in their design and construction were radically different. The Forth Bridge has all its compression members of tubular construction and all connections between the different truss members are rigidly riveter. In the Quebec Bridge the compression

members are built of parallel webs latticed while the main tension members are of eye-bars; pin connections have been used throughout the trusses instead of riveted joints. In the Forth Bridge plates were shipped from the mills to the bridge site where they were bent, punched or drilled and fitted into place plate by plate, and the number of workmen in the field is said to have reached, at a certain time, six thousand. The Quebec

Fig. 40. Arch bridge at Coblenz.

Bridge members were manufactured in shops specially constructed for this work, and shipped in large units to the bridge site, where driving of pins and some riveting was all that was necessary to assemble the structure. It is true that the Quebec work required much heavier lifting and handling-machinery than the single plates of the Forth Bridge, but, on the other hand, the required amount of labor in the field was greatly reduced and a comparatively small force was used. In each instance, however, the particular method was justified. The Forth Bridge method by the cheapness of labor at the time and place of its building and the Quebec Bridge method by the improved erection machinery and greatly increased cost of labor.

REINFORCED CONCRETE

Within recent years a new heterogeneous material has come into wide use in engineering, not only for bridges but for other structures as well. Mehan and Monnier first demonstrated the value of steel reinforcement of concrete. There are now many

examples of reinforced concrete bridges. As is usually the case with new things in construction, many failures have occurred; but the lessons from such failures together with theory, laboratory tests and the succesful structures, go to make up the knowledge of correct design. This knowledge is not yet complete; one may say that it is in its infancy although it is growing rapidly; with a tendency to more caution and better judgment and less struggle for economy which is often only apparent and always dangerous.

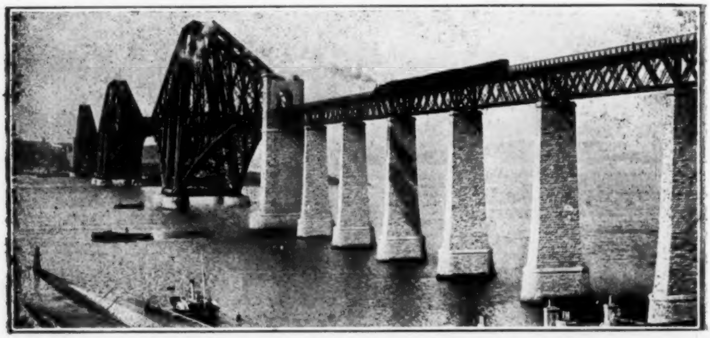

Fig. 41. Firth of Forth Scotland.

BRIDGE CONSTRUCTION IN THE UNITED STATES

We have seen that wood was used in Europe as bridge material in the very beginning of civilization. In the United States, wood was again largely resorted to at first, in the early rapid development of its means of transportation. This, however, was due entirely to economic considerations, both from the point of expense and of celerity. During the very rapid development of the railroads in this country, it became necessary at first to use the cheapest and quickest means of bridging. The wooden truss was therefore used extensively during the first growth of the railroads and highways, to be replaced later by a more substantial and permanent form of construction. Among the early wooden structures, we are told of a quite remarkable one built by Louis Wernwag in 1813. It was a bridge over the Schuylkill River which had a span of 340 feet, supposedly the longest wooden bridge ever built in the United States. After several systems of wooden construction had been tried, with more or less success, the wooden Howe truss, in-

vented by William Howe, made its appearance. The first structure of this type was built in 1840. It was a highway bridge with a 75-foot span. Due to its simplicity, facility and quickness of construction, the system soon became generally used by nearly all the railroads in this country. Even to this date those wooden truss bridges may be seen on some less prosperous railroad lines.

With the expanding iron industries, wrought and cast iron soon replaced wood, but the necessity still existed for quick and easy erection of bridges in the field, with the least amount of labor and machinery, and therefore engineers were exerting their ingenuity to invent systems of trussing which would meet those requirements. And so there came a period of the various systems, such as Bollman, Fink, Post, Linville, Pettit, Warren, Pratt, etc., most of which are now obsolete.

These systems were all based on connecting the truss members by pins, which greatly reduced the work of assembling in the field. The pin-connected system is characteristic of American bridges and marked a great advance in this branch of engineering. It is now being replaced in smaller spans by riveted connections but in long truss spans, it is still the most practical method of construction.

In these early times of bridge construction in this country, or prior to 1880, the metals used were wrought and cast iron exclusively; the only exception being the Eads Bridge in St. Louis, in which Captain Eads used chrome steel for the first time; and excepting steel used in the wires of suspension bridges, some of which were built prior to that year. In the meantime, iron mills began to manufacture steel, first Bessemer, then open hearth, and gradually cast iron was replaced by wrought iron which, in turn, was replaced by Bessemer steel and finally by the open-hearth steel which is now generally used.

In recent years alloys of steel have been used more and more —nickel steel, chrome-nickel steel and silicon steel. These materials, because of their increased strength, prove economical for long spans. For the same reason, they also make it possible to build longer spans than could practically be done with ordinary steel. We have not yet reached the full possibilities of alloys as bridge materials, and we may expect still greater progress in this direction.

Since the introduction of the metal truss, the form of trussing has undergone very marked changes due not only to progress in manufacture and in facilities for work in the field, but also to wider experience and the better understanding of theory. And so, as has been said before, many of the early ingenious systems bearing the names of their inventors were gradually abandoned until now only two of them are used, the Warren and the Pratt systems; the so-called sub-divided Pratt system, usually being given preference for long spans. The earlier

Fig. 42. Bismarck Bridge, North Dakota.

through-bridges had trusses generally with parallel chords; later, trusses with parabolic top chords for independent spans, when the spans were of sufficient length, came into almost exclusive use. The Bismarck Bridge in North Dakota is one of the many examples of this change. Three four-hundred-foot spans, built in 1883 with trusses of double intersection Howe system with parallel chords, were replaced in 1905 by spans of the same length having trusses of the sub-divided Howe system and parabolic top chords (Fig. 42).

The United States, because of the rapid growth of its railways and the magnitude of its streams, offers the greatest opportunity of any country for the development of the science and knowledge of bridge-building. Unfortunately, we have now entered upon an era of standard specifications and each

engineering society of any size is bent upon compiling its own. So that an engineer desiring to secure somewhat better material for his structure is met by objections from the manufacturer who claims that if the standard specifications of such and such society are good enough the engineer should be content with them. This automatically arrests any effort on the part of the contractor to produce better material than what is known by him as "commercial product" and thus progress in the manufacture of materials of higher grade quality for bridge work is retarded. The material is not improving in quality—it is even deteriorating. Standard specifications are an advantage in many cases, but not in regulating the product of industries which are still almost in their infancy and in progress of development.

But the modern-bridge engineer is far from having the privileges of Pontifex Maximus. Leupold quotes the following interesting description of those privileges:

"What great consideration the bridges and their conservation occupied with the ancients and especially with the Romans is sufficiently illustrated by the following:

"That the office of building and conserving such (bridge) should be given and entrusted to a person bearing the title of a Pontifex Maximus, which person was *exempt* above all other persons and even possessed the highest direction of the then pagan service of God, and who completely possessed all power in religious matters to do and to let as he found fit. Yea, the position was so great and important that a great emperor, Augustus, and after him many other pagan and Christian emperors, attached this title to their imperial dignity. And while the Christian emperors did not apply such office in a pagan way, they utilized it as Christians to represent by it the highest person in spiritual as well as in the worldly society. For, a Pontifex Maximus was bound by no law and did not have to give account of his doings to the people nor to the Council; could not be called for penalty; no one dared attack him by word; kept such dignity and office during his lifetime; no one equal to him was appointed; could let himself be carried into the Capitolium, which was not permitted to any other man and besides was an asylum for persecuted criminals."

And if we wish to know what requirements one had to possess to be a bridge engineer two hundred years ago, one should read in Leupold's work the following:

"Since bridge-building is to be considered as being among the foremost and most important works of man, in which all human understanding, wisdom, experience, in fact, all arts and sciences, must cooperate, such an 'Architecto' must not only be experienced in arithmetic and geometry, so as to be able to measure precisely the length, breadth and depth of a stream, to plat all this correctly and accurately on a geometrical plan, to estimate quantities of all materials, as stone, timber, lime, iron work, and finally, to determine the cost of construction; but he must also be a good physicist, to well understand all properties of the materials of construction and distinguish between their faults and merits, particularly, which wood is best, when it should be cut and to what purpose each kind serves; also the properties of the water, of the ice, how and where it exerts its greatest force and how such a force can best be overcome; he must above all have a good understanding of the ground and bottom of the river in which the piles or piers are to stand; he must also have a sufficient knowledge of mechanics, partly to indicate or apply machinery for procuring, lifting and lowering the large beams, piles, stones, etc., and for driving piles by means of convenient hammers; partly to be able to indicate various methods for lifting the water out of cofferdams, or to drive the cofferdams themselves, and to lift the water from around the piers or where it is desired to reach the ground; and, above all, he must be a good carpenter and stone mason, both being equally the foremost and principal part in the building of a bridge; because if the bridge is entirely of wood, then it falls entirely to the carpenter; if, however, it is of stone, then has the carpenter one of the most important works to perform in building scaffolding and centres, and the stone mason must not let his art be without experience either; and the knowledge of the law of gravity is here mainly required so one would know how the bodies press and where the greatest effort comes and where those forces can best be resisted; to sum up, there are so many things required that space is here to small to touch upon all of them."

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Cooperative Work in the Organization of Local Material for General Science Instruction: Water Supply Systems. (*Continued*)

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OUTLINE

I. Introduction
II. Part 1. The Oakland, California, Water Supply System.
III. Part 2. The Water Supply System of Cleveland, Ohio.
IV. Part 3. The Water Supply System of Muskogee, Oklahoma.
V. Part 4. The Philadelphia Water Supply System.
VI. Part 5. The New York Water Supply System.

Lesson I. Sources of Water.

Part III. The Muskogee Oklahoma, Water Supply System.

PROBLEM: To study the different sources from which water may be obtained for the home, community, and commercial uses.

ASSIGNMENT:

1. Name as many water supply sources as you can, (Place the names of all these sources on the blackboard, divide the class into groups, assign a source to each group, and let the pupils get all the information they can on the source assigned.)
2. Make a list of the uses of water in your community. In other communities.
3. What do you know concerning the Muskogee Water Supply System, and what would you like to know about it?

CLASS DISCUSSION:

(Reports were given on the different sources of water and each pupil took notes on all important points given in class.)

1. Give the advantages and disadvantages of securing water from rivers, lakes, wells, artesian wells, oceans, and springs.
2. From which of the sources mentioned does Muskogee secure its water?
3. Discussion on the uses of water.

Lesson II. History of the Muskogee Water Supply.

Assignment:

Read the newspapers and pamphlets (which may found in the City Library and at the city offices) on the history of the Muskogee Water System.

Class Discussion:

1. Early history up to 1911.
2. 1911-1921.
3. Money invested.
4. Efficiency of system.
5. Purity of water.
6. Supply of water.
7. Pressure in case of a big fire.
8. Construction of a softening and purifying plant.
9. Construction of a settling basin.
10. Construction of an intake.
11. Construction of a garbage disposal plant.
12. Pumps.
13. Erection of reservoir on Agency Hill.
14. Improvements, and extension of the sewer system from the city to the Arkansas River.
15. Growth of Population.
    a. 1900-1910.
       1910-1920.
    b. Why is the city of Muskogee growing so rapidly?
    c. With the increase in population will the water supply ever be exhausted?
16. Ownership of water supply.
    a. Who owns the system?
    b Who controls the system?
    c. Is the system under public control?
    d. Is it better and more economical for each family to be responsible for its water supply or for the community to do this for all?
    e. Give the advantages and disadvantages in each case.
17. Preparations for the trip to the waterworks. (Preparations were made on Friday so that

the class could spend Saturday at the waterworks.)

a. Permission to visit water works.

b. Snap shots of interesting things seen at the pumping station on the trip.

c. Meeting place, street car, and time to meet.

d. The lunch.

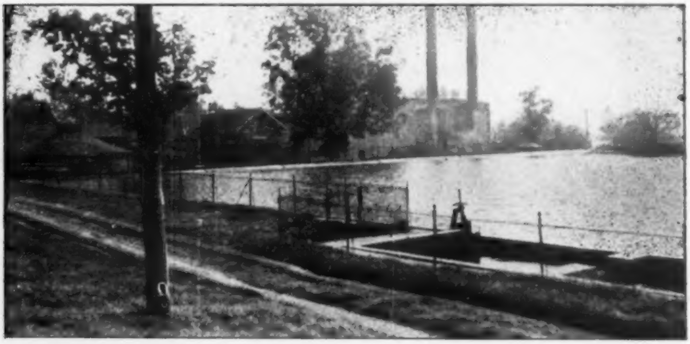

Fig. 1. The pumping station and settling basin of the water supply system of Muskogee, Oklahoma.

Lesson III. . A Trip to the Waterworks of Muskogee. (See Fig. 1)

PROBLEM: A trip to the pumping station and waterworks to learn about the Muskogee water supply. (Outline for the excursion. A copy to be placed in the hands of each pupil. Notes were taken on things that were examined during the trip.)

OBSERVATIONS:

1. Location of water sources.
2. Where does the water come from?
3. How is the water brought to the pumping station?
4. How far away is the source of supply?
5. Do fish or animals live in the water?
6. Do plants grow in or upon the water?
7. Examine the low duty pump, high duty pump, and water mains.
8. Treatment of water in chemical house
9. Fifty-six inch main under Arkansas River.

10. Well, eighty feet deep.
11. Pipes, kinds used.
12. Settling basin, size, capacity, and number of sections.
13. Soil examined.
14. Are fertilizers used in the neighborhood?

Lesson IV. Discussion of Class Excursion.

I. Sources of water of Muskogee.

Problem: To give each pupil a knowledge of the sources of water of Muskogee.
(Information for the following lessons was obtained from notes which pupils took while on the trip, from newspapers, and from pamphlets on the Muskogee water system.)

Questions:

1. What river supplies water for Muskogee?
2. How is the water brought to the pumping station?
3. Is there a reservoir or standpipe?
4. What precautions are taken to prevent impurities in the water?
5. Do fish live in the water?
6. Does the kind of soil or fertilizers affect the water?
7. Do you think the water is pure? Give reasons.
8. What are algae? Would you think them of benefit to a water system?
9. Do fish improve the quality of the water?

Assignment:

Questions on the methods of transferring the water in Muskogee.

Lesson V. Discussion of Class Excursion (Continued)

II. Methods of Transferring the Water in Muskogee.

Problem: To enable pupils to understand how the water which they use is transferred from its source to their homes and to the different parts of the city.

Questions:

1. How is the water brought to the pumping station?

2. How is the water brought from its source to the city? To the reservoir?
3. What is the course and capacity of the chief water mains?
4. Are pumps used? Is a standpipe used?
5. How is the water pressure maintained?
6. How is the extra pressure for fighting fires secured?
7. What is the water pressure at the average street level? At the top of the highest building?
8. What are the regulations concerning the use of free water for churches, city parks, cemeteries, charitable institutions, public libraries, sewage systems, streets, and fire hydrants?

ASSIGNMENT:

Questions on the consumption of water in Muskogee.

Lesson VI. Class Discussion on Excursion (Continued).

III. Consumption of water

PROBLEM: To give the pupil an estimate of the amount and cost of the water which is used in homes and in other parts of the city.

QUESTIONS:

1. How much water do you use in your home each month?
2. What does it cost to furnish water to your home for one month?
   (Each student found out how much water was used in the home each month and reported to the class.)
3. How much water is used daily?
4. What are the local water rates?
5. Are water meters used in every home?
6. Who owns the meters?
7. Who keeps them in repair
8. How many consumers are paying for water at a flat rate? At commercial rates?
9. What is the population of the community?
10. What is the total cost of the water system?

11. What is the per capita cost of the system?
12. What is the annual cost of operation of the water supply system?

Lesson VII. Distillation of Water.

PROBLEM: Can dirty water be made suitable for use by distillation?

APPARATUS:

Flask, hydrant water, ring stand, cork-stopper, delivery tube, test tube, beaker of cold water, coloring matter, Bunsen burner.

WHAT TO DO:

Fill the flask one-half full of colored hydrant water, and support it in a ring stand. Put a piece of wire gauze between the flask and the flame. Use a cork stopper and a bent delivery tube and catch the distilled water in a test tube standing in a beaker of cold water.

RESULTS:

1. What is distillation?
2. When water containing impurities is boiled, what becomes of the impurities?
3. Is boiled water safe to dring ? Explain.
4. What is the taste of distilled water?
5. Is the water clear and without sediment?

Lesson VIII. Filtering Water.

PROBLEM: How is water purified by filtration?

APPARATUS:

Glass funnel, glass bottle, filter paper, and powdered chalk.

WHAT TO DO:

Make a filter by folding a circular filter paper through the middle and then fold each half. Press the folded edges between the thumb and forefinger, but not between the nails. Open the paper so that it forms an inverted cone, and fit the cone exactly into the funnel. Hold the filter in the funnel, wet it with water, and press it carefully against the glass. Place the funnel in the bottle. Mix powdered chalk with water and pour the milky mixture upon the filter. What happens?

Mix thoroughly half a teaspoonful of fine sand with the same amount of powdered salt. Put the mixture into a dish and add to it half a test tube full of hot water.

Make another filter. Stir the mixture of sand, salt, and water, and pour the solid and liquid together upon the filter. Catch the part that runs through in a dish and evaporate some of it on a glass plate over a cup of boiling water.

RESULTS:

What substance do you obtain?

QUESTIONS:

1. Is the pollution of streams caused by necessity or carelessness?
2. Why is the water of a mountain lake commonly supposed to be free from disease producing bacteria? Is such water always safe?
3. Give a number of ways by which water may be made impure.
4. Give a number of ways by which water may be made pure.
5. Which method does Muskogee use to purify the water ?
6. Name some of the dangerous and harmful impurities which may be found in domestic water supply.
7. Are any of these impurities found in the Muskogee water?
8. What diseases are often spread by impure water? How are they spread?
9. Has any disease ever been traced to Muskogee water supply?
10. Is it possible to tell by merely looking at or tasting the water, whether it is safe to drink?
11. Describe the purification system of Muskogee as to method, size, capacity, and efficiency.
12. What chemicals are used in the water?
13. How often is the water tested by experts?
14. Are household filters commonly used? Are they safe?
15. Where should a well be located?
16. Is clear sparkling water always pure?

Lesson IX. Character of the Water. (See Fig. 2)

PROBLEM: Is Muskogee supplied with hard water?

APPARATUS:

Soap, 3 test tubes, distilled water, hard water, and hydrant water, powdered calcium sulphate, gypsum or plaster of Paris

WHAT TO DO:

Put a small piece of soap into a test tube half full of distilled water. Close the tube with your thumb, and shake it vigorously. Then let it stand for five minutes.

Fig. 2. The chemical house of the water supply system of Muskogee, Oklahoma.

Do the same with a test tube half full of hydrant water, and with one half full of very hard water. Hard water may be made by shaking some powdered calcium sulphate (gypsum or plaster of Paris) with water and then filtering the solution.

RESULTS:

1. Which forms the best and most lasting lather or suds?
2. Compare the results in the three tubes.
3. What differences do you see?
4. Which leaves a scum? (See Fig. 3)
5. If the ability to form a lasting suds is a test for a good laundry water, which of the three is the best?
6. Which water would waste the most soap?
7. Do you think the scum would be a good thing for the clothing washed?

Lesson X. Character of the Water (Continued).

PROBLEM: Does the water contain organic matter?

APPARATUS:

Beakers, graduated cylinders, cardboard or glass cover, dilute sulphuric acid, potassium permanganate solution, distilled water, pond water and hydrant water.

WHAT TO DO:

Measure 50 cc. each of distilled water, hydrant water, and pond water. Put each kind of water into a clean glass beaker. Add to each beaker 2 cc.

Fig. 3. A close view of the settling basin of the water supply of Muskogee, Oklahoma.

of dilute sulphuric acid and one drop of potassium permanganate solution. Cover the three vessels with cardboard or glass covers and set them aside in a warm room. Let them stand several hours.

RESULTS:

1. In which case is the pink color changed most? In which least?
2. Does the water contain organic matter that changes the potassium permanganate?
3. Which sample has the most of it?

Lesson XI. A Trip to the Reservoir which is Located on Agency Hill.

OUTLINE FOR THE EXCURSION.

(A copy is furnished each pupil.)

OBSERVATIONS:

1. What is the shape, capacity, and depth of the reservoir?

2. How many feet higher than the city is the reservoir?
3. How far is the reservoir from the business center?
4. How many feet above sea level is the water level when the reservoir is full?
5. Is the reservoir area guarded partially or completely?
6. How is the water brought from the reservoir to the homes?
7. Do plants grow in or upon the water?

ASSIGNMENT:

Questions for a study of the sewage system.

Lesson XII. The Sewage System.

PROBLEM: What becomes of the sewage?

QUESTIONS:

1. What is the final destination of waste water?
2. What is the course of the chief sewers?
3. Describe the sewage disposal plant.
4. Is there any possibility of the sewage contaminating the water source?

SOURCES OF INFORMATION

I. SOURCES OF WATER

1. Van Buskirk and Smith. "The Science of Everyday Life."
2. Hessler. "First Year of Science."
4. Bedford "General Science".
5. Elhuff. "General Science."
6. Caldwell and Eikenberry. "Elements of General Science."

II. GENERAL

1. Pamphlets on the Muskogee water system.
2. Newspapers.

III. PURIFICATION OF WATER

1. Caldwell, Eikenberry and Glenn. "Elements of General Science: Laboratory Problems."
2. Hessler. "Laboratory Exercises."

LESSONS FOR EIGHTH GRADE PUPILS

PERIODS 60 MINUTES

Recitations 35 Minutes.

Supervised Study 25 Minutes.

LABORATORY WORK 60 MINUTES

Book Review

A Little Book on Water Supply—William Garnett—144 pages—illustrated—The Macmillan Company.

The water supply is a common science topic which requires more material than is contained in the text. This book on water supply, even though an English production and has accordingly relatively fewer references to American water systems than to English, is a valuable book for the project worker. The science discussions apply to practically all water supplies alike. Among such topics are: nature's water supply; hard and soft water; aqueducts; springs and wells; pumps and air lifts; bacteria; service pipes and the effect of storage.

Practical Physics (Revision)—N. Henry Black and Harvey N. Davis—555 pages—580 illustrations—The Macmillan Company.

This is a revision of the popular text issued a few years ago and contains 68 pages more than the old edition. The improvement over the former book lies in the added applications to common things and the introduction of matter relating to radio. Its appeal to pupils will be even stronger than was its predecessor if that is possible.

Person Hygiene Applied—Jesse F. Williams—412 pages—$2.50—W. B. Saunders Company, Phila.

"The aim of this book is to improve the quality of human life." There can be no doubt that this aim will be reached in the case of every person who carefully reads and heeds the teachings of this book. It is the most practical and helpful personal hygiene that we have had the good fortune to examine. In the words of the author "It aims to present facts in human experience, to establish science and intelligence as guides, and to replace superstition, cults, fads, traditions and certain instinctive responses with truer counsellors. In this respect it is expressing a dominant mood in education today, and takes its position courageously, asking that truth shall decide, let the results seem what they may." The book is planned for college students. It is equally good for normal schools and as a reference work in high schools. Even the general reader would profit from a frequent use of this book.

Purposeful Handiwork—Jane W. McKee—108 pages—illustrated The Macmillan Company.

This little volume will help the kindergartener and lower grade teachers. It is rich in suggestions of things to make and includes a number of scientific toys. It is well illustrated with pictures and diagrams. A chapter on "Supplies and Accommodations" gives a list of specific things needed to carry on this work in a kindergarten-primary unit.

The Professional Education of Teachers in Cleveland—92 pages—paper covers—$.50—Board of Education, Cleveland, Ohio.

This is a report concerning the work and possibilities of the Cleveland School of Education in affiliation with the Western Reserve University. It was prepared under the auspices of the Cleveland Foundation by William C. Bagley, John W. Withers and George C. Chambers.

A Manual for School Administrators—Frederick A. Welch—145 pages—W. M. Welch Manufacturing Company.

This manual is the outgrowth of twenty years of experience as superintendent in village and city schools and gives information of practices in various school systems. It is a volume which helps one to understand the workings of the present school system. It treats historical development, school officers, equipment, course of study, organization, administration, supervision, social centers, activities, the teacher and her work, board of education, and a forward look.

Live Stock and Farm Mechanics—John H. Gehrs—393 pages—164 illustrations—the Macmillan Company.

For the rural boy in the grades or high school this book should make a strong appeal. The practical work which it covers will so fit into his daily experiences that he will be greatly benefited. About half the book deals with live-stock and the remainder with farm mechanics and farm management. There are valuable suggestions at chapter ends on laboratory exercises and home projects.

Farm Projects—Carl Colvin and J. A. Stevenson—363 pages—68 illustrations—The Macmillan Company.

This agricultural text, written for seventh and eighth grades and junior high schools, is designed for a two year course. The forty-four sections of this book offer a wide range of project work which is treated in language well suited to the boy of high school age. Special emphasis is laid on giving the pupil the proper point of view at the very beginning of the course. The aim is to make the school work so fit into the home work that it will count in dollars and cents as well as in making home tasks easier.

The Cinema Handbook—A. C. Lescarboura—illustrated—507 pages Scientific American Publishing Company.

Here is a book for the non-theatrical worker who is interested in motion pictures. "It is intended for the naturalist, traveler, explorer, microscopic worker, teacher, engineer, and others who would aspire to seeing their work on the screen." The ground covered is as follows: principles of motion picture, apparatus selecting, proper type of camera, accessories, operation and care of camera, developing and printing the film, projectors, projecting and caring for the positive film, the animated album, planning and filming, screen advertising, telling the business story in film language, the acetate film, special applications of motion picture photography, miscellaneous data and formulae.

High School Geography—R. H. Whitbeck—577 pages—383 illustrations—8 colored maps—The Macmillan Company.

This book attempts and succeeds in the attempt to show the interrelation of the physical environment of man and human activities, The idea of this interrelation is indicated by the two chapters "Materials of the earth's crust" and "Mineral resources and industries of the United States". Part one deals with the United States. Part two takes up the outstanding features of Latin America, the British empire, Continental Europe, China, and Japan. Valuable summaries and exercises are found at chapter ends. On the whole, it is an especially attractive volume.

Magazine List

American City. The Tribune Building, N. Y. C. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 25 E. 26th St., New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation and experiments in nutrition.

Commercial America. Phila. Com'l Museum, Phila., Pa., $2.00 a year. Ill. Commercial production. New Inventions. Will interest Commercial geography and science teachers.

Current Opinion. 65 W. 36 St., N. Y. Monthly. 35c a copy, $4.00 a year. Has a regular department "Science and Discovery" containing articles of popular interest, adapted to pupil or teachers.

The Educational Screen—5200 Harper Avenue, Chicago. Monthly 15c copy, $1.00 a year. Discusses the use of movies in our schools; gives brief descriptions of educational films and lists theatrical films which are suitable for children. The journal is entirely educational having no commercial affiliations.

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy, $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Geographical Review. Broadway at 156th St., N. Y. Quarterly $1.25 a copy, $5.00 a year. Devoted to scientific geography. Original maps and pictures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Illustrated World. Drexel Ave. and 58th St., Chicago. Monthly. 25c a copy, $3.00 a year. Many short articles on applications of science and mechanics. Popular in style and attractive to elementary and high school pupils.

Industrial Education Magazine. Peoria, Illinois. Monthly. $1.50 a year, 25c a copy. An illustrated magazine which is indispensable to the shop instructor and to others who would "keep up" in industrial education.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 1121 Cathedral St., Baltimore. Monthly. 25c a copy, $2.50 a year. For teachers.

Journal of Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

The Literary Digest. 354 Fourth Ave., N. Y. Weekly. 10c a copy, $4.00 a year. Has a department "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

Moving Picture Age. Chicago. 15c a copy, $1.00 per year, montly. Devoted to the interests of visual instruction. A helpful journal to teachers.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high grade pictures. Articles are of interest to general reader, pupils and teachers, as well as to geographers.

Nature Study Review. Ithaca, N. Y. Monthly. 20c a copy, $1.50 a year. An illustrated journal for teachers of nature study.

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles well illustrated. Appeals strongly to elementary pupils. Suggest many construction projects.

Popular Science Monthly. 255 West 39th St. N. Y. C. Monthly. $3.00 a year, 25c a copy. A Review in text and pictures of the news of science and invention presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Practical Electrics. New York City. 20c a copy, $2.00 per year monthly. This is especially suggestive to boys who are making things electrical. There are numerous articles on electrical topics.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Review of Reviews. 30 Irving Place, N. Y., N. Y. Monthly. 35c a copy, $4.00 a year. An illustrated monthly covering world affairs. Contains many good articles bearing on science, suitable for class reports.

Safety Engineering. 80 Maiden Lane, New York. Monthly. $3.00 a year. 25c a copy. A journal devoted to conservation of life and property and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Scientific American. Woolworth Building, N. Y. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated and is particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place, N. Y. C. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles as a rule are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

The Screen. 114 West 44th St., N. Y. Monthly. 10c a copy. $1.00 a year. Articles on use of motion pictures and descriptions of films.

Transactions of the Illuminating Engineering Society. 29 W. 39th St., N. Y. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.

Visual Education. 806 W. Wash. Blvd., Chicago. Monthly. 15c a copy. $1.00 a year. Discusses films, film making and the various visual aids for school use.